DEPARTMENT OF THE NAVY
SPACE AND NAVAL WARFARE SYSTEMS COMMAND
ARLINGTON VA 22245-5200

SPAWARINST 5100.12B
SPAWAR 00F
19 July 1994

SPAWAR INSTRUCTION 5100.12B

From: Commander, Space and Naval Warfare Systems Command

Subj: NAVY LASER HAZARDS CONTROL PROGRAM

Ref: (a) Federal Performance Standard for Light Emitting Products 21 CFR Part 1040
(b) ANSI Z136.1-1993 American National Standard for the Safe Use of Lasers R
(c) Safety and Health Construction Standards 29 CFR 1926.54 and 1926.102(b) (2)
(d) SECNAVINST 5100.14B
(e) OPNAVINST 5100.23 series, chapter 22 A
(f) MIL-STD-1425A Safety Design Requirements for Military Exempt Lasers and Associated Support Equipment
(g) NAVMEDCOMINST 6470.2 series
(h) E0410-BA-GYD-010 Technical Manual, Laser Safety
(i) MIL-STD-882C
(j) OPNAVINST 5102.1D
(k) ANSI Z136.2 American National Standard for the Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources A
(l) ANSI Z136.3 American National Standard for the Safe Use of Lasers in Health Care Facilities A
(m) NAVFACINST 11010.44 Chapter 10 A
(n) MIL-HDBK-828 Laser Range Safety A
(o) BUMEDINST 6470.19 Laser Safety for Medical Facilities A

Encl: (1) Requirements and Procedures of the Laser Safety Review Board
(2) Guidelines for Submission of a Laser Data Package
(3) Laser Safety Review Board Meeting Agenda Outline
(4) Military Laser Exemption Notification Format
(5) Laser Data Worksheet
(6) Eye Protection Review Request Form
(7) Activity Laser Hazard Control Program
(8) Operations, Maintenance, and Training Requirements for Laser Hazard Control
(9) Safety Requirements for Military and Industrial Laser Ranges and Maintenance Areas
(10) Laser Classification and Labeling
(11) Military Exempt Laser Inventory Format
(12) Class 3b and Class 4 Laser Inventory Format
(13) Laser Safety Requirements Summary

1. Purpose. To prescribe Navy policy and guidance in the identification and control of laser radiation hazards.

2. Cancellation. SPAWARINST 5100.12A is cancelled and superseded.

3. Scope. The provisions of this instruction are mandatory for all Navy and Marine Corps activities. They apply to the design, use, and disposal of all equipment and systems capable of producing laser radiation including laser fiber optics. This document has been coordinated with members of the Navy Laser Safety Review Board which includes all Navy and Marine Corps Systems Commands, Marine Corps Headquarters, Bureau of Medicine and Surgery (BUMED), Navy Environmental Health Center (NEHC) and Naval Safety Center (NAVSAFECEN).

4. Definitions

a. Laser. An acronym for Light Amplification by Stimulated Emission of Radiation. Any device which can be made to produce or amplify electromagnetic radiation in the x-ray, ultraviolet, visible, and infrared or other portions of the spectrum by the process of controlled stimulated emission of photons.

b. Laser Classifications. The four laser hazard classifications which determine the extent of radiation safety controls required. These range from class 1 lasers which are inherently safe for direct beam viewing under all conditions to class 4 lasers which require the strictest of controls. Laser product classification pertains to normal laser operation only. When a laser product is disassembled for maintenance, etc., and protective features removed, the laser classification may change to a more hazardous class. Details concerning laser classification are contained in references (a) and (b) and enclosure (10). Controls for each class are addressed in this instruction and references (b) through (e).

c. Incidental Worker. One who does not work routinely with lasers. One whose work makes it possible but unlikely that the individual will be exposed to laser energy sufficient to damage the eyes or skin. This includes but is not limited to military personnel on maneuvers, or custodial, clerical, and supervisory personnel not working directly with laser devices. A

d. Laser System Safety Officer (LSSO), Category 1. One who has successfully completed both the technical and the management portions of Naval Occupational Safety and Health and Environmental Training Center LSSO Category 1 Course. See enclosure (8). A

e. Laser System Safety Officer (LSSO), Category 2. One who has successfully completed the management portion of the Naval Occupational Safety and Health and Environmental Training Center LSSO Category 2 Course, or another SPAWAR approved Category 2 LSSO management course. See enclosure (8). A

f. Laser Worker. One who works routinely in laser environments. This individual is ordinarily fully protected by engineering controls, administrative procedures, or both. A

g. Military Exempt Lasers. Lasers designed for actual combat, combat training operations, or classified in the interest of national security, and thus exempted from the requirements of reference (a). Their design must comply with reference (f).

h. Nominal Hazard Zone. The space within which the level of the direct, reflected, or scattered radiation may exceed the applicable maximum permissible exposure level (MPE).

i. All other terms relating to lasers shall be those given in references (a) and (b).

5. Background

a. The widespread use of lasers in both commercial and military applications has increased the probability of exposure to injury from laser radiation. References (a) through (o) have been issued to provide controls over laser design and operation for protection of personnel and equipment. Reference (a) promulgates safety design and data regulations for all non-exempt lasers. Reference (c) provides occupational safety and health regulations for construction lasers. Reference (d) addresses laser products which are exempt from the requirements of reference (a) and assigns laser

safety responsibilities. Reference (e) requires the establishment of laser safety and health programs and provides criteria for the protection of personnel from laser radiation. Design requirements for military exempt lasers are given in reference (f). Reference (g) establishes reference (b) as the Navy standard for laser hazard evaluation, control, and protection and provides for medical surveillance and action in cases of suspected overexposure. Safety precautions and guidance for protection of Navy personnel from specific military lasers are published in reference (h). Reference (i) provides system safety statements of work for use in contracts for the design of laser systems, as well as other systems. Accidents involving lasers are reported in accordance with references (e) and (j).

b. Reference (k) describes methods of controlling laser hazards introduced by fiber optics technology.

c. Reference (l) describes methods of controlling laser hazards in medical applications.

d. Reference (m) addresses laser safety certification in the facilities site approval process.

e. Reference (n) provides the DOD methodology for evaluating hazards at laser ranges and establishing uniform laser range safety procedures.

f. Reference (o) establishes laser safety requirements in medical facilities.

6. Policy. It is Navy policy to identify and control laser radiation hazards early during design and development as a matter of military necessity.

7. Responsibilities

a. SPAWAR 00F is designated by reference (d) as lead agency for laser safety and shall serve as the single point of contact and authority within the Navy in this regard. SPAWAR 00F shall:

(1) Establish and publish Navy laser safety design standards and training requirements.

(2) Evaluate laser protective devices.

(3) Ensure the capability exists to conduct a laser safety survey, measurement, and review for all Navy lasers, laser installations, laser ranges and target areas. Actual services should be provided by SPAWAR-designated laboratories on a cost reimbursable basis.

(4) Provide the chairman and secretariat for the Navy Laser Safety Review Board (LSRB) as described in enclosure (1).

(5) Maintain an inventory of all Navy military exempt lasers and class 3b and class 4 lasers.

(6) Coordinate with Deputy Under Secretary of Defense for Environment and Safety (DUSD (ES)) via Assistant Secretary of the Navy (Installations and Environment) (ASN (I&E)) all Navy initiated requests for disposal and transfer approvals of exempted lasers.

(7) Advise DUSD (ES) via ASN (I&E) of any substantial changes in laser safety policy affecting exempted lasers after coordination with BUMED.

(8) Represent the Navy in tri-service and other interagency laser safety matters and support BUMED in regard to laser radiation medical surveillance.

(9) Prepare, publish, and maintain reference (h) for use by the operating forces, Systems Commands, and shore activities. Reference (h) describes laser safety responsibilities, basic principles of optics and laser radiation, biological effects of laser radiation, laser safety design and procedural requirements, maximum permissible exposure (MPE) levels of laser radiation, optical densities required for protection against military laser sources selected by the LSRB, a nominal list of sources for laser eye protection, hazard distances of military lasers selected by the LSRB, and laser hazard evaluation procedures.

b. The LSRB shall, in accordance with enclosures (1), (2), and (3), review all classes of military exempt lasers, including those used in optical fiber communication systems, and all other class 3b and class 4 laser systems except those planned solely for experimental laboratory use. The composition of the LSRB is defined in the next paragraph. R

c. All Systems Commands, the Bureau of Medicine, Marine Corps, and Naval Safety Center shall provide a permanent and alternate member to the LSRB in accordance with enclosure (1). The names, telephone numbers of the members, and their security clearances shall be forwarded to Commander, Space and Naval Warfare Systems Command (SPAWAR 00F).

d. Commanders of all Systems Commands, all Navy and Marine Corps program directors and project managers, research and development activities, the Bureau of Medicine, and all medical activities shall fund and conduct the laser safety program within their cognizant material support areas. They shall:

(1) Apply system safety methods according to reference (i) throughout all life cycle phases of laser systems, laser test fixtures and laser facilities for new systems and modification or different applications of an existing system.

(2) Review the purpose of proposed lasers to determine if they shall meet reference (a) or qualify as military exempt. Exempted lasers shall be designed in accordance with reference (f) and as many of the standards of reference (a) as practical. Standards replacing those in reference (a) shall be as safe. Unclassified lasers that are intended primarily for indoor classroom training and demonstration, industrial operations, scientific investigations, or medical applications shall not be exempted.

(3) Grant exemptions from reference (a) and impose reference (f) on manufacturers designing military exempt lasers. Procurement or contracting officers shall grant exemptions in writing. A laser exemption format is given in enclosure (4).

(4) Ensure that all classes of military exempt lasers are reviewed by the LSRB. Provide also for LSRB review of all other class 3b and class 4 lasers, except those planned solely for experimental laboratory use. Obtain these reviews before program advancement to the next stage of development, and before test, prototype, or production units are introduced into the fleet. Resubmit systems for LSRB review when new applications are planned. R

(5) Ensure that the SPAWAR 00F-designated Navy laboratory, Naval Surface Warfare Center (NAVSWC) Dahlgren Division (Code G71), participates in design reviews, evaluates compliance with MIL-STD-1425, and measures laser output to determine nominal ocular hazard distances (NOHDs) and other safety related parameters of all lasers to be reviewed by the LSRB prior to the review.

(6) Provide to the LSRB, at least one month prior to laser reviews, safety test data, measurements, hazard evaluations of the laser, corrective actions, and other system safety activities conducted according to reference (i) and enclosure (2) of this instruction. A format for reporting laser data is outlined in enclosure (5). An eye protection review request form is provided in enclosure (6) and shall also be submitted to SPAWAR 00F prior to the LSRB review.

(7) Implement the recommendations of the LSRB.

(8) Provide laser protective devices for operating and maintenance personnel and recommend protection for other personnel or material at risk.

(9) Include all necessary laser safety data in laser technical manuals, maintenance requirement cards (MRCs), operational manuals, and training curricula.

e. Navy commands and activities at which class 3b lasers and class 4 lasers are used, shall: (Note: Activities having lasers with Class 3a lasers labeled with a "danger logo" shall caution their employees to treat these lasers as if they were class 3b but need not assign a laser system safety officer.) R

(1) Establish laser safety organizations according to reference (b) and enclosures (7) through (9).

(2) Impose design and operating requirements of this instruction and reference (f) on equipment and facilities. Provide adequate warnings, safety training, documentation, and audits for the control of all hazards resulting from the use of lasers at their activities. Ensure all lasers are classified as to hazard and labeled per enclosure (10).

(3) Appoint laser system safety officers (LSSOs) and forward their names, codes, and telephone numbers to Commander, Space and Naval Warfare Systems Command (SPAWAR 00F).

(4) Ensure that only those laser installations and ranges which have been approved by the activity LSSO as safe for specific applications are allowed to operate and then solely for those applications. Technical assistance is available from SPAWAR approved laboratories to enable Commanding Officers and their LSSOs to certify the safety of their laser ranges. R

(5) Use and dispose military exempt lasers in compliance with references (d) and (h). Obtain approval of SPAWAR 00F prior to disposal.

(6) Submit an annual inventory of all military exempt lasers and all class 3b and class 4 lasers as defined in enclosure (10) to Commander, Space and Naval Warfare Systems Command (SPAWAR 00F) by 31 August of each year. A sample format for submission of military exempt laser data is given in enclosure (11). A sample format for submission of class 3b and class 4 data is given in enclosure (12). It is preferable that the inventory of military exempt lasers be reported by a central logistics manager whenever possible.

(7) Report all laser radiation exposure incidents to BUMED (MED-21) within 20 days of the incident per reference (g) and to the Naval Safety Center in accordance with references (e) and (j). Also provide copies of the report to Commander, Space and Naval Warfare Systems Command (SPAWAR 00F) and, if not classified, to the National Center for Devices and Radiological Health, Electromagnetic Radiation Branch, 12709 Twinbrook Parkway, Rockville, MD 20852. Report near misses to Commander, Space and Naval Warfare Systems Command (SPAWAR 00F) within 30 days of occurrence.

(8) Coordinate all space directed emissions with:

Headquarters U.S. Space Command/J3SOCO
Suite 9-101
1 NORAD Rd.
Cheyenne Mountain AFB, CO 80914-6020

Space Defense Operations Center (SPADOC)
Laser Clearinghouse
DSN 268-3510, (719) 575-3510
Significant parameters to be reported are operating wavelength, beam divergence and output power.

W. H. Cantrell

W. H. CANTRELL
Rear Admiral, U.S. Navy

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SPAWAR 10-16K (Room 113, SPAWAR Directives and Forms)

REQUIREMENTS AND PROCEDURES OF THE LASER SAFETY REVIEW BOARD

1. Laser Safety Review Board (LSRB). The LSRB, hereinafter referred to as the Board, has been established to assure that laser safety criteria are incorporated in all Navy laser systems. The Space and Naval Warfare Systems Command is charged with providing the chairmanship and secretariat and supplying administrative support.

2. Scope. All classes of military exempt Navy lasers and all commercial class 3b and class 4 Navy laser systems not designed solely for laboratory or medical use shall be reviewed by the Board to determine the hazards presented by the laser especially with respect to laser radiation during all phases of development, use, maintenance, transportation, storage and disposal.

3. Composition. The Board shall be an independent authority on laser safety. It shall be formed of representatives from CNO, BUMED, NAVSAFECEN, CMC, and the five Systems Commands under the chairmanship of the Safety Office, Space and Naval Warfare Systems Command. A permanent secretariat shall be provided by the Space and Naval Warfare Systems Command. Personnel assigned as members of the Board shall be experienced in laser safety and have no responsibility for the development or effectiveness of the item under review. Designated Board members should seek assistance in technical documentation review and may request attendance of technical experts from Navy laboratories. NAWC, Warminster and NSWCDD, Dahlgren are tasked to assist in this regard.

4. Responsibilities. The Board shall review the hazardous aspects of each laser system presented to assure that all safety requirements including design features, procedures, precautions and training are included in the laser installation and documentation. Having established the degree of safety incorporated in the laser system, the Board through the chairman renders a judgment as to safety certification and presents its recommendation regarding advance of the system to the next stage of the logistic cycle. Specific responsibilities are as follows:

a. The Chairman of the Board shall:

(1) Convene the Board as deemed necessary when requested by the design cognizant agent.

(2) Preside at Board meetings.

(3) Assure functions of the Board are implemented.

(4) For each laser presented, issue recommendations of the LSRB to the responsible agent.

(5) Periodically report actions of the Board to the Commander, Space and Naval Warfare Systems Command.

b. The Secretariat shall:

(1) Schedule Board meetings as required.

(2) Provide technical and administrative support to the Board.

(3) Promulgate reports generated by the Board.

(4) Maintain the official files of the Board.

c. Members shall:

(1) *Review technical documents presented prior to the Board meetings.*

(2) Render an independent appraisal of the laser safety aspects along with a recommendation concerning safety approval of the item under review. All phases of the life cycle are to be considered, with emphasis given to the life cycle phases of specific concern to the command represented.

d. All Navy and Marine Corps Program/Project Managers and Commanding Officers of Research and Development Activities, per SECNAVINST 5100.14B, shall:

(1) Ensure that all items listed in paragraph 2 above are submitted to the Board for review at appropriate times throughout the life cycle (Concept Exploration and Definition, Demonstration and Validation, Engineering and Manufacturing Development, Operation and Support phases).

(2) As described in enclosure (2), submit to the Board a document package on the item for review no less than 30 days prior to the established meeting date. The document package shall be sent to each member of the LSRB. LSRB addresses will be supplied by Space and Naval Warfare Systems Command, SPAWAR 00F, upon request.

(a) Are there interlocks to prevent inadvertent firing?

(b) Are there hardware and software programs to prevent laser operation in unauthorized areas?

(c) What is the system aiming accuracy (boresight error, boresight retention, platform stability, etc.)?

(d) Are there provisions for performing quarterly boresight checks, accompanied by documentation?

(e) Has a laser safety training program been provided for operations and maintenance personnel? When, where, and what is the typical course content?

(f) Has a medical surveillance program for all personnel involved been coordinated with BUMED?

(g) For what targets has the system been reviewed and certified safe?

(17) Do associated support equipment and facilities comply with MIL-STD-1425?

(18) Has the contracting officer notified the contractor in writing concerning military exempt lasers per enclosure (4)?

(19) In response to notification by the contracting officer that the laser under contract is military exempt, has the contractor identified those design requirements of 21 CFR Part 1040 which cannot be incorporated in the system, and provided rationale for noncompliance?

GUIDELINES FOR SUBMISSION OF A LASER DATA PACKAGE

1. The content of the document package and the presentation is mainly affected by two considerations:

a. The complexity of the item to be presented.

b. The point in the life cycle in which the review is conducted.

2. The later in the life cycle the review is attempted, and the more complex the item, the more voluminous the available data for presentation will be. The following guidelines are presented to assist in preparing for the Laser Safety Review Board (LSRB). The exact content of the presentation and the document package is the prerogative of the cognizant program manager. Advice and assistance may be sought from the secretariat located in SPAWAR 00F. The following is typical of information submitted.

a. Documentation should be sufficiently complete and detailed to allow a meaningful review of all laser safety aspects by LSRB members prior to the presentation. It should completely describe:

(1) The design of the system. A full set of design drawings is not desired, but rather documents such as assembly drawings, firing circuits, or other sketches which would indicate or assist in describing the system. Emphasis should be put on components, hardware, software, and human factors affecting safety.

(2) The operation of the system. A concise but thorough description of the intended use of the system including maintenance, storage areas, use environment, handling equipment, laser platform, performance sequence, disposal methods, etc.

(3) Safety features of the system. Describe the system safety program plan and its results including a list of all types and scopes of hazard analyses. Observations made during development, test, and evaluation which bear on laser safety should be presented. All safety devices incorporated in the system as well as precautionary measures to be invoked in use are to be identified. Also required is the extent to which the system meets the requirements of applicable standards, specifications and safety controls.

(4) Documentation and Training Support for the System. Verify that the required publication and training programs have been developed to assure the safe operation, training, handling, transportation, storage and disposal of the laser system.

b. The major theme of the presentation should be the system safety program results with design and operation being covered only to the depth necessary to support the safety conclusions. While a definite time limit cannot be established, it is suggested that the presentation be limited to two hours.

c. Technical Assistance. All measurements for hazard determination will be performed by a government laboratory designated by SPAWAR 00F.

(1) For laser related weapon systems and certification of laser firing ranges, contact the Naval Surface Warfare Center, Code G71, Dahlgren, VA, 22448, DSN 249-8171, commercial (703) 663-8171. Range surveys are also conducted by the Naval Warfare Asssessment Division, (NWAD) Naval Ordnance Center Code SE41, Corona, CA 91720-5000, DSN 933-5430, commercial (714) 273-4139.

(2) For medical and industrial laser operations, contact the Navy Environmental Health Center, Code 31, 2510 Walmer Avenue, Norfolk, VA 23513-2617, DSN 564-4657, commercial (804) 444-4657.

(3) For laser eyewear device evaluation, contact the Naval Air Warfare Center, Code 6023, Warminster, PA, 18974-5000, DSN 441-1089, commercial (215) 441-1089.

(4) Requests for assistance may be directed to the Space and Naval Warfare Systems Command (SPAWAR 00F), 2451 Crystal Drive, Arlington, VA 22245-5200, DSN 222-7235, commercial (202) 692-7235; or the Bureau of Medicine and Surgery (MED 2122), Washington, DC, 20372-5120, DSN 294-1182, commercial (202) 653-1182.

d. Laser safety parameters which are usually presented to the Board in order to evaluate hazard control are the following:

(1) Output energy or power, pulse width, maximum repetition rate, beam diameter, and wavelength.

(2) Secondary beams and collateral radiation.

(3) Beam divergence at 1/e (67 percent of beam energy) points.

(4) Hot spots.

(5) Hazardous diffuse reflections.

(6) Diffuse hazard distance.

(7) Nominal ocular hazard distances (NOHD) for unaided vision and with optics of 5 cm, 8 cm and 12 cm.

(8) Eye protection specifications.

(9) Skin hazard distance.

(10) Test and evaluation of protective devices.

(11) Platform stability.

(12) Beam stop control method.

(13) Calculated and measured tracking or aiming accuracy.

(14) Method of establishing cutouts for control of beam azimuth and elevation.

(15) Boresight determination method.

(16) Boresight error.

(17) Boresight retention.

(18) Inadvertent beam focusing conditions.

(19) Maintenance and use conditions.

(20) Hazard sign usage.

(21) Test plans.

(22) Provisions for training.

(23) Land/sea/air laser system safety officer (LSSO) qualifications, as applicable.

(24) Laser safety bills for land/sea/air use.

(25) Range safety evaluation results.

e. Typical LSRB questions are the following:

(1) Has a system safety program according to MIL-STD-882C been initiated?

(2) What is the laser type and wavelength?

(3) Does the system meet and comply with MIL-STD-1425, 21 CFR, and ANSI Z136.1?

(4) What is the laser classification?

(5) Does it present a hazard to materials?

(6) Is the system military exempt? If so, why, and does it comply with SECNAVINST 5100.14B and MIL-STD-1425?

(7) If military exempt, to what extent does it not comply with 21 CFR and why?

(8) What are the eye hazard and skin hazard distances for direct beam and diffuse reflections?

(9) Have these distances been measured and calculated?

(10) How are they measured and calculated?

(11) What is the means to warn the operator that the system is on?

(12) Does system operation require at least two independent actions?

(13) What means is there to avoid unauthorized firing?

(14) What protective devices are supplied in system optics or for other personnel in the area during maintenance and operation? Do the protective devices protect against all wavelengths that could be encountered in an operational or maintenance environment?

(15) Are operating and maintenance shops properly designed with door interlocks, warning signs, and lights? Do they comply with MIL-STD-1425?

(16) Operation - Explain operational safety features such as the following:

LASER SAFETY REVIEW BOARD MEETING AGENDA OUTLINE

1.	Call to Order and Statement of Purpose	Chairman
2.	Introduction of Board Members	Chairman
3.	Technical Presentation	Cognizant Activity
4.	Discussion	Open
5.	Laser Safety Review Board (LSRB)	Members Caucus
6.	Discussion (if needed to clarify points raised during caucus)	Open
7.	Rendering of LSRB Decision	Chairman

LASER DATA WORKSHEET

SECTION I - Laser Inventory

1. General

a. Laser Custodial Information

(1) Contracting Activity: _____

(2) Unit Identification Code (UIC): _____

(3) Controlling Activity: _____

(4) Custodian's Name: _____

(5) Custodian's Phone: _____

(6) LSSO Name/Phone: _____

b. Laser Identification

(1) Laser Type _____

(2) Manufacturer: _____

(3) Class: _____

(4) System Name: _____

(5) Joint Electronic Type Designation System Name:

AN/ _____

(6) Serial Number(s): _____

(7) Contract Number: _____

(8) National Stock Number: _____

(9) Plant Account Number(s): _____

(10) Location(s) and number of lasers: _____

(11) Laser Uses: _____

_____

(12) Source of laser characteristics _____

NOTE: If this laser system can be operated in both pulse and CW mode then the analysis of both Section II and Section III must be conducted for each laser in the system.

(13) Military Exempt Lasers (Check if not applicable: _____)

Basis for exemption:

Combat___, Combat Training:___, Classified:___

SECTION II - Pulsed Lasers

1. PULSED LASER HAZARDS ANALYSIS

a. Laser Characteristics (Indicate whether (M) measured data or (S) specifications/ estimates).

(1) Laser Type/Medium: _____

(2) Wavelength(s) (λ) micrometers (μm) or nanometers (nm): _____

(3) Pulse repetition frequency (PRF): _____

(4) Scan Rate in Hertz (Hz): _____

(5) Beam Cross Section

Circular: _____ Rectangular: _____ Elliptical: _____

Other (Identify:: _____

(6) Beam Diameter or rect./ellipt. dimensions (cm): a=____or a_1=____a_2=____
"a" must be at 1/e. a @ 1/e = $a/2^{1/2}$ @ $1/e^2$

(7) Beam Divergence in radians @ 1/e or f number:ϕ=___ or ϕ_1=___ ϕ_2=___ f=_

ϕ at 1/e = $\phi/2^{1/2}$ at $1/e^2$

(8) Q = Energy per Pulse, in joules (J): _____

b. Maximum Permissible Exposures (MPEs)

(See ANSI Z136.1 for definitions. For MPE_5 (Intrabeam Viewing), MPE_{EXT} (MPE_5 * C_E, Diffuse Reflection and Extended Source Viewing), and MPE_7 (Skin Exposure) values, refer to Tables 5, 6, and 7 of ANSI Z136.1.)

(1) t = Single Pulse Duration: _____

(2) F = prf = Pulse Repetition Frequency: _____

(3) T = Estimated Maximum Personnel Exposure Duration:

Hours: _____ Minutes: _____ Seconds: _____ N/A: _____

(4) n = Total Number of Pulses During Exposure (F)*(T): _____

(5) nt = Total On-time of Beam During Exposure =(F)(T)(t): _____

(6) Does the pulse duration change with a change in the laser system mode of operation? Yes ___ No ___. If so, how?

(7) Single Pulse MPEs (Exposure duration = pulse duration)

(a) Direct Intrabeam Viewing (MPE_5): _____

(b) Skin Exposure (MPE_7): _____

(8) Repetitive Pulse MPE's Direct Intrabeam Viewing

(a) Wavelengths from 280 nm to 400 nm

(24 hr exposure)
MPE_5/number of pulses in 24 hr = MPE per pulse _____

(>24 hr. exposure)
Divide 24 hr MPE per pulse by 2.5 _____

(See ANSI Z136.1, Paragraph 8.2.2.1),

(b) Wavelengths 400 nm to 1.4μ

Worst Case of either

MPE per pulse = MPE_5 (for duration T)/number of pulses (n) _____
or
MPE per pulse = MPE_5 (for single pulse duration) * $n^{-1/4}$ _____

For wavelengths 400 to 700 nm, accidental staring T is 0.25 seconds or T is duration of intentional staring into the beam.

For wavelengths 700 nm to 1.4 μ accidental staring T is 10 seconds or T is duration of intentional staring into the beam.

(See ANSI Z136.1, Paragraph 8.2.2.2 and Appendix B3.1.2, Examples 3 to 7)

(c) Wavelengths 1.4 μ to 1 mm

Worst Case of either

MPE per pulse = MPE_5 * $n^{-1/4}$ _____
or
MPE average power = 0.1 Watt = (n*Q/T) _____

(Accidental staring T is 10 seconds or T is duration of intentional staring into the beam.)

(9) Diffuse Reflection/Extended Source Viewing:

For wavelengths 400 to 700 nm, accidental staring T is 0.25 seconds or T is duration of intentional staring. The value C_E must also be calculated to correlate with the duration T.

For wavelengths 700 nm to 1.4 μ accidental staring T is 10 seconds or T is duration of intentional staring. The value C_E must also be calculated to correlate with the duration T.

Wavelengths 400 nm to 1.4μ

(See ANSI Z136.1, Table 6, Paragraph 8.2.2.2 and Appendix B3.2.2, Examples 8 to 10)

D_1 (Laser beam diameter) = _____

r_1 (minimum distance from diffuse/extended source)
(assume 20 cm if r_1 is unknown) = _____

$\alpha = D_1/r_1$

α_{min} for exposure duration T = _____

C_E = (See ANSI Z136.1-1993 Table 6) _____

number of pulses (n) in duration T. n = _____

MPE_{EXT} (per pulse) = C_E * MPE_5 * $n^{-1/4}$ (per pulse) _____ J/cm^2

(10) Repetitive Pulse MPE's for Skin

Whichever is less, Single pulse MPE_7 corrected for multiple pulses or MPE_7 for Average irradiance for total pulse train where MPE per pulse = MPE_7 (for duration T)/number of pulses (n) _____ or multiply MPE by $n^{-1/4}$.

At wavelengths greater than 1.4 μ for T > 10 sec and beam cross sectional areas between 100 cm^2 and 1000 cm^2, where A_s = Area of exposed skin in cm^2, average irradiance MPE = $10,000/A_s$ = _____

For beam cross section irradiatiang 1000 cm^2 or more of skin, MPE = 10 mw/cm^2
MPE per pulse = average irradiance MPE/n = _____

c. Limiting Aperture (ANSI Z136.1, Table 8) D_f = _____

2. Results

a. Accessible Emission Limit ($MPE*(\pi D_f^2/4)$) _____

b. Laser Hazard Class (use AEL and ANSI Z136.1 Table 2) _____

c. $H_o = 1.27\ Q/a^2$ = _____

d. Optical Densities

(1) Optical Density (unaided) (OD) = $\log_{10}(H_o/MPE_5)$
where H_o is the emergent beam radiant exposure at zero range: OD_____

(2) In most instances optical aids are 7 x 50 binoculars, 8 cm tank viewing optics or 12 cm ship's "BIGEYE". They have an approximate $G^{1/2}$ equal to 7, 11.4, and 17.1 respectively. When the beam diameter is larger than the objective lens of the optical aid then:

$OD_{aided} = \log_{10}(H_oG/MPE_5)$ = OD_____

If the beam diameter is smaller than the objective lens of the optical aid then:

$OD_{aided} = Log_{10}[(Q/0.385\ cm^{2)}/MPE]$ = OD_____

where G = Ratio of retinal irradiance or radiant exposure received by the optically aided eye to that received by the unaided eye. G is determined as follows:

d_e = Pupil diameter of the eye in millimeters (mm)
D_e = Effective Exit pupil diameter of optical device (mm)
P = Magnifying power of optical device
D_o = Objective lens diameter (mm)
$D_e = D_o/P$

MILITARY LASER EXEMPTION NOTIFICATION FORMAT 19 JUL 1994

1. The following or equivalent statement shall be used to notify the contractor that a laser product is exempt from 21CFR, chapter 1, subchapter J.

"In accordance with Exemption No. 76EL-01DOD to the Department of Defense on July 26, 1976, by the Commissioner of Food and Drugs, the following electronic product is exempted from Food and Drug Administration (FDA) radiation safety performance standards prescribed in the Code of Federal Regulations, Title 21, Chapter 1, Subchapter J.

Laser Type/Medium _____

Manufacturer _____

Number of Lasers _____

National Stock Number (if available) _____

Reason for exemption:

(Check one)

Combat _____

Combat Training _____

Classified _____.

2. Laser products exempted under 76EL-01DOD shall be labeled by the manufacturer as follows:

CAUTION

This electronic product has been exempted from FDA radiation safety performance standards prescribed in the Code of Federal Regulations, Title 21, Chapter 1, Subchapter J, pursuant to exemption No. 76EL-01DOD issued on July 26, 1976. Use this product only with adequate protective devices or procedures.

3. The contractor must comply with MIL-STD-1425A as stipulated in the contract, identify those design requirements of 21 CFR Part 1040 which cannot be incorporated in the system, and provide rationale for noncompliance with each requirement.

(b) **NOHD (unaided G = 1, $\mu \neq 0$)**

single pulse NOHD = _____

repetitive pulse NOHD = _____

(c) **NOHD ((aided $G^{1/2}$ = 7, 11.4, 17.1), μ = 0)**

single pulse NOHD = _____ _____ _____

repetitive pulse NOHD = _____ _____ _____

(d) **$NOHD_{aided}$ ($G^{1/2}$ = (7, 11.4, 17.1), $\mu \neq 0$)**

single pulse $NOHD_{aided}$ = _____ _____ _____

repetitive pulse $NOHD_{aided}$ = _____ _____ _____

Note: At wavelengths longer than 1 micron, $G^{1/2}$ may be multiplied by 0.7, since transmission through glass optics is reduced at these wavelengths.

(2) Intrabeam Skin Hazard Distance

Use the following equation to solve skin hazard distances

For circular beam:

$$HD = \frac{1}{\phi}\sqrt{\frac{1.27Qe^{-\mu r}}{MPE_7} - a^2}$$

For elliptical beam:

$$HD = \frac{1}{\phi_1\phi_2}\sqrt{\frac{\sqrt{(a_1^2\phi_2^2+a_2^2\phi_1^2)^2 - 4\phi_1^2\phi_2^2\left(a_1^2a_2^2 - \left[\frac{1.27 \cdot G \cdot Q \cdot e^{-\mu r}}{MPE_7}\right]^2\right)} - (a_1^2\phi_2^2+a_2^2\phi_1^2)}{2}}$$

For rectangular beam:

$$HD = \frac{1}{\phi_1\phi_2}\sqrt{\frac{\sqrt{(a_1^2\phi_2^2+a_2^2\phi_1^2)^2 - 4\phi_1^2\phi_2^2\left(a_1^2a_2^2 - \left[\frac{G \cdot Q \cdot e^{-\mu r}}{MPE_7}\right]^2\right)} - (a_1^2\phi_2^2+a_2^2\phi_1^2)}{2}}$$

HD (skin, μ = 0, single pulse) = _____

HD (skin, μ = 0, repetitive pulse) = _____

CONDITIONS	INTRABEAM VIEWING	DIFFUSE REFLECTION VIEWING
If $d_e \geq D_e$	$G = D_o{}^2/d_e^2$	$G = D_o{}^2/Pd_e^2$
If $d_e \leq D_e$	$G = D_o^2/D_e^2 = P^2$	$G = D_o^2/PD_e^2$

e. Nominal Ocular Hazard Distances (NOHDs) and Other Hazard Distances

(1) Intrabeam Viewing NOHDs

For clearest atmospheric conditions, let $\mu = 0$.

In the visible and near infrared for typical conditions, $\mu = 5 \times 10^{-7}$ cm-1. See Figures 5-1, 5-2, and 5-3 of enclosure (5). μ = _____

Use the appropriate one of the following equations to determine Nominal Ocular Hazard Distances (NOHD).

For circular beams:

$$NOHD = \frac{1}{\phi}\sqrt{\frac{1.27 \cdot G \cdot Q \cdot e^{-\mu r}}{MPE_5} - a^2}$$

For elliptical beam:

$$NOHD = \frac{1}{\phi_1 \phi_2}\sqrt{\frac{\sqrt{(a_1^2\phi_2^2 + a_2^2\phi_1^2)^2 - 4\phi_1^2\phi_2^2\left(a_1^2a_2^2 - \left[\frac{1.27 \cdot G \cdot Q \cdot e^{-\mu r}}{MPE_5}\right]^2\right)} - (a_1^2\phi_2^2 + a_2^2\phi_1^2)}{2}}$$

For rectangular beam:

$$NOHD = \frac{1}{\phi_1 \phi_2}\sqrt{\frac{\sqrt{(a_1^2\phi_2^2 + a_2^2\phi_1^2)^2 - 4\phi_1^2\phi_2^2\left(a_1^2a_2^2 - \left[\frac{G \cdot Q \cdot e^{-\mu r}}{MPE_5}\right]^2\right)} - (a_1^2\phi_2^2 + a_2^2\phi_1^2)}{2}}$$

NOTE: If there is a beam waist in front of the laser, r_0 must be added to the NOHD and the minimum beam waist diameter must be substituted for the exit beam diameter.

Distance from exit port to beam waist formed in front of laser r_0 = _____

(a) **NOHD (unaided G = 1, μ = 0)**

single pulse NOHD = _____

repetitive pulse NOHD = _____

HD (skin, $\mu \neq 0$, cm^{-1}, single pulse) = _____

HD (skin, $\mu \neq 0$ cm^{-1}, repetitive pulse) = _____

(3) DIFFUSE REFLECTION HAZARDS

(See ANSI Z136.1, B3.2.2/3, Examples 8 to 10)

Viewing distance (r_1) is generally 20 cm or greater from a diffuse reflector or extended source (most adults cannot focus closer than 20 cm.) r_1 (cm) = _____

α_{min} = (See ANSI Z136.1, Paragraph 8.1 and Table 6, Note 1) _____

Beam Diameter (D_L or D_ρ) of extended source or laser beam at diffuse surface, D_L or D_ρ (cm) = _____

$\alpha = D_\rho / r_1$ = _____

C_E = (See ANSI Z136.1 Table 6) _____

$MPE_{EXT} = MPE_5 * C_E$ = _____

Diffusely reflected beam energy, Q_{EXT}, which does not exceed MPE_{EXT} at distance r_1: (See ANSI Z136.1 Table 3 or use the following equation)

(let $\rho_\lambda \cos\theta = 1$) $$Q_{EXT} = \frac{\pi \cdot MPE_{EXT} (r_1 + D_\rho/2)^2}{\rho_\lambda \cos\theta} =$$ _____

Diffuse reflection hazard at r_1: Is $Q > Q_{EXT}$? _____
(If yes, continue to compute diffuse hazard distances)

$$r^*_{1max} = \frac{D_L}{\alpha_{min}} =$$ _____

$$r^{**}_{1(safe)} = \sqrt{\frac{\rho_\lambda \cdot Q}{\pi \cdot MPE_5}} =$$ _____

If $r_{1(safe)} > r_{1(max)}$ then the hazard distance is $r_{NHZ1} = r_{1(safe)}$

$$r^{***}_{NHZ1}(\alpha < \alpha min,) = \sqrt{\frac{\rho_\lambda \cdot Q \cdot \cos\theta_v}{\pi \cdot MPE_5}} =$$ _____

If $r_{1(safe)} < r_{1(max)}$ then the hazard distance is r_{NHZ2}

$$r^{***}_{NHZ2}(\alpha min < \alpha < 0.1 rad) = \frac{\rho_\lambda \cdot Q \cdot \cos\theta_v}{\pi \cdot MPE_5 \cdot r_{1max}} =$$ _____

If $r_{NHZ2} < 10D_\rho$ then the hazard distance = $10D_\rho$

$$r^*_{NHZ}(Skin) = \sqrt{\frac{\rho_\lambda \cdot Q \cdot \cos\theta_v}{\pi \cdot MPE_7}} =$$ _____

$$r_{diffuse}^{****} = \frac{1}{\Phi}\sqrt{\frac{1.27Q}{\pi \cdot MPE_{EXT}} - D_L^2} =$$

Notes

* r_{1max} – distance beyond which an extended source or diffuse reflector must be considered a point source.

** $r_{1(safe)}$ – safe viewer distance from diffuse reflector when beyond r_{1max}. Note that this is the same as r_{NHZ} for $\alpha < \alpha_{min}$ and $\cos\theta_v = 1$.

*** r_{NHZ} – minimum safe viewing distance for looking at a diffuse target with reflectivity ρ_λ at wavelength λ with a viewing angle of θ_v from beam line of sight. This is also the border of the nominal hazard zone (NHZ).

**** $r_{(diffuse)}$ – distance of laser from diffuse reflector to prevent a hazardous diffuse reflection to an observer at a viewing distance less than 10 times the laser beam diameter (distance within which image brightness on the retina remains constant). To compute C_E correction factor for MPE_{EXT} assume that most adults will be 20 cm from the diffuse surface and estimate laser beam diameter on the diffuse surface from knowledge of the intended laser location. Diameter of beam waist and distance, r_0, from the exit port to any beam waist formed in front of laser, must also be considered.

NOTE: Since MPE_{EXT} is range dependent, this equation cannot be solved in closed form. Iterative techniques are required.

SECTION III - CW Lasers

1. CW LASER HAZARDS ANALYSIS

a. Laser Characteristics (Indicate whether (M) measured data or (S) specifications/ estimates).

(1) Laser Type/Medium: _____

(2) Wavelength(s) (λ) micrometers (μm) or nanometers (nm): _____

(3) Scan Rate in Hertz (Hz): _____

(4) Beam Cross Section

Circular: _____ Rectangular: _____ Elliptical: _____

Other (Identify:: _____

(5) Beam Diameter or rect./ellipt. dimensions (cm): a=____or a_1=____a_2=____
"a" must be at 1/e. a @ 1/e = $a/2^{1/2}$ @ $1/e^2$

(6) Beam Divergence in radians @ 1/e or f number:ϕ=___ or ϕ_1=___ ϕ_2=___ f=_

ϕ at 1/e = $\phi/2^{1/2}$ at $1/e^2$

Identify whether obtained at 1/e: ___ or $1/e^2$: _____

(7) Φ = Power output, in watts (W): _____

b. Maximum Permissible Exposures (MPEs)

(See ANSI Z136.1 for definitions. For MPE_5 (Intrabeam Viewing), MPE_{EXT} (MPE_5 * C_E, Diffuse Reflection and Extended Source Viewing), and MPE_7 (Skin Exposure) values, refer to Tables 5, 6, and 7 of ANSI Z136.1.)

(1) MPE's Direct Intrabeam Viewing

(a) Wavelengths from 280 nm to 400 nm

(24 hr exposures)
(MPE_5 in J/cm^2)/(Total Exposure time) for entire 24 hr period =_____W/cm2

(>24 hr. exposures)
Divide 24 hr MPE by 2.5 _____W/cm^2

(See ANSI Z136.1, Paragraph 8.2.2.1),

(b) Wavelengths 400 nm to 1.4μ

For wavelengths 400 to 700 nm, accidental staring exposure duration T is 0.25 seconds or use the actual time T for intentional staring into the beam.

For wavelengths 700 nm to 1.4 μ accidental staring T is 10 seconds or use the actual time T for intentional staring into the beam.

(See ANSI Z136.1, Paragraph 8.2.2.2 and Appendix B3.1.2, Examples 3 to 7)

Choose whichever is worst case:

MPE (per exposure duration T) = (MPE_5 in J/cm^2)/T _____ W/cm^2

or

MPE = MPE_5 (W/cm^2) _____ W/cm^2

(c) Wavelengths 1.4 μ to 1 mm

(Accidental exposure duration T is 10 seconds or T is duration of intentional exposure in the beam.)

Worst Case of either:

MPE (per exposure duration T) = (MPE_5 in J/cm^2)/T _____ W/cm^2

or

MPE = 0.1 $Watt/cm^2$ for exposures from 10 to 3×10^4 sec. _____ W/cm^2

(2) Diffuse Reflection/Extended Source Viewing:

For wavelengths 400 to 700 nm, accidental staring T is 0.25 seconds or T is duration of intentional staring. The value C_E must also be calculated to correlate with the duration T.

For wavelengths 700 nm to 1.4 μ accidental staring T is 10 seconds or T is duration of intentional staring. The value C_E must also be calculated to correlate with the duration T.

Wavelengths 400 nm to 1.4μ

(See ANSI Z136.1, Table 6, Paragraph 8.2.2.2 and Appendix B3.2.2, Examples 8 to 10)

D_1 (Laser beam diameter) = _____

r_1 (minimum distance from diffuse/extended source) (assume 20 cm if r_1 is unknown) = _____

$\alpha = D_1/r_1$

α_{min} for exposure duration T = _____

C_E = _____

MPE_{EXT} (per exposure duration T) = C_E * (MPE_5 in J/cm^2)/T _____ W/cm^2

or

$MPE_{EXT} = C_E * MPE_5$ (W/cm^2) _____ W/cm^2

(3) MPE's for Skin

(a) Wavelengths from 280 nm to 400 nm

(24 hr exposures)

(MPE_7 in J/cm^2)/(Total Exposure time) for entire 24 hr period = _____ W/cm2

(>24 hr. exposures)
Divide 24 hr MPE by 2.5 _____ W/cm^2

(See ANSI Z136.1, Paragraph 8.2.2.1),

(b) Wavelengths 400 nm to 1.4μ

For wavelengths 400 to 700 nm, accidental exposure duration T is 0.25 seconds or use the actual time T for intentional exposure in the beam.

For wavelengths 700 nm to 1.4 μ accidental exposure T is 10 seconds or use the actual time T for intentional exposure in the beam.

Choose whichever is worst case:
MPE (per exposure duration T) = (MPE$_7$ in J/cm^2)/T _____ W/cm^2
or
MPE = MPE$_7$ (W/cm^2) _____ W/cm^2

(c) Wavelengths 1.4 μ to 1 mm

(Accidental exposure duration T is 10 seconds or T is duration of intentional exposure in the beam.) Choose worst case of either

MPE (per exposure duration T) = (MPE$_7$ in J/cm^2)/T _____ W/cm^2
or
MPE = 0.1 Watt/cm^2 for exposures from 10 to 3 x 10^4 sec. _____ W/cm^2

and at wavelengths greater than 1.4 μ for T > 10 sec and beam cross sectional areas between 100 cm^2 and 1000 cm^2, where A_s = Area of exposed skin in cm^2, average irradiance MPE = 10,000/A_s = _____
or for beam cross section exposing >1000 cm^2 of skin, MPE = 10 mw/cm^2 _____

c. Limiting Aperture (ANSI Z136.1, Table 8) D_f = _____

2. Results.

a. Accessible Emission Limit (MPE*($\pi D_f^2/4$)) _____

b. Laser Hazard Class (use AEL and ANSI Z136.1 Table 1) _____

c. E_o = 1.27 Φ/a^2 = _____

d. Optical Densities

(1) Optical Density (unaided) (OD) = $\log_{10}(E_o/MPE_5)$
where E_o is the emergent beam irradiance at zero range: OD_____

(2) In most instances optical aids are 7 x 50 binoculars, 8 cm tank viewing optics or 12 cm ship's "BIGEYE". They have an approximate $G^{1/2}$ equal to 7, 11.4, and 17.1 respectively. When the beam diameter is larger than the objective lens of the optical aid then:

OD_{aided} = $\log_{10}(E_oG/MPE_5)$ = OD_____

If the beam diameter is smaller than the objective lens of the optical aid then:

OD_{aided} = $Log_{10}[(E_o/0.385\ cm^{2)}/MPE]$ = OD_____

where G = Ratio of retinal irradiance of radiant exposure received by the optically aided eye to that received by the unaided eye. G is determined as follows:

d_e = Pupil diameter of the eye in millimeters (mm)
D_e = Effective Exit pupil diameter of optical device (mm)
P = Magnifying power of optical device
D_o = Objective lens diameter (mm)
$D_e = D_o/P$

CONDITIONS	INTRABEAM VIEWING	DIFFUSE REFLECTION VIEWING
If $d_e \geq D_e$	$G = D_o{}^2/d_e^2$	$G = D_o{}^2/Pd_e^2$
If $d_e \leq D_e$	$G = D_o^2/D_e^2 = P^2$	$G = D_o^2/PD_e^2$

e. Nominal Ocular Hazard Distances (NOHDs) and Other Hazard Distances

(1) Intrabeam Viewing NOHDs

For clearest atmospheric conditions, let $\mu = 0$.

In the visible and near infrared for typical conditions, $\mu = 5 \times 10^{-7}\ cm^{-1}$. See Figures 5-1, 5-2, and 5-3 of enclosure (5). $\mu =$ _____

Use one of the following equations as appropriate to determine Nominal Ocular Hazard Distances (NOHD).

For circular beams:

$$NOHD = \frac{1}{\Phi}\sqrt{\frac{1.27 \cdot G \cdot \Phi \cdot e^{-\mu r}}{MPE_5} - a^2}$$

For elliptical beams:

$$NOHD = \frac{1}{\Phi_1 \Phi_2}\sqrt{\frac{\sqrt{(a_1^2\Phi_2^2 + a_2^2\Phi_1^2)^2 - 4\Phi_1^2\Phi_2^2(a_1^2a_2^2 - [\frac{1.27 \cdot G \cdot \Phi \cdot e^{-\mu r}}{MPE_5}]^2)} - (a_1^2\Phi_2^2 + a_2^2\Phi_1^2)}{2}}$$

For rectangular beams:

$$NOHD = \frac{1}{\Phi_1 \Phi_2}\sqrt{\frac{\sqrt{(a_1^2\Phi_2^2 + a_2^2\Phi_1^2)^2 - 4\Phi_1^2\Phi_2^2(a_1^2a_2^2 - [\frac{G \cdot \Phi \cdot e^{-\mu r}}{MPE_5}]^2)} - (a_1^2\Phi_2^2 + a_2^2\Phi_1^2)}{2}}$$

NOTE: If there is a beam waist in front of the laser, r_0 must be added to the NOHD and the minimum beam waist diameter must be substituted for the exit beam diameter.

Distance from exit port to beam waist formed in front of laser r_0 = _____

(a) NOHD (unaided G = 1, μ = 0) _____

(b) NOHD (unaided G = 1, $\mu \neq 0$) _____

(c) NOHD ((aided $G^{1/2}$ = 7, 11.4, 17.1), μ = 0) _____

(d) $NOHD_{aided}$ ($G^{1/2}$ = (7, 11.4, 17.1), $\mu \neq 0$) _____

Note: At wavelengths longer than 1 micron, $G^{1/2}$ may be multiplied by 0.7, since transmission through glass optics is reduced at these wavelengths.

(2) Intrabeam Skin Hazard Distance

Use the following equation to solve skin hazard distances

For circular beam:

$$HD=\frac{1}{\Phi}\sqrt{\frac{1.27\Phi e^{-\mu r}}{MPE_7}-a^2}$$

For elliptical beam:

$$HD=\frac{1}{\Phi_1\Phi_2}\sqrt{\frac{\sqrt{(a_1^2\Phi_2^2+a_2^2\Phi_1^2)^2-4\Phi_1^2\Phi_2^2(a_1^2a_2^2-[\frac{1.27\cdot G\cdot\Phi\cdot e^{-\mu r}}{MPE_7}]^2)}-(a_1^2\Phi_2^2+a_2^2\Phi_1^2)}{2}}$$

For rectangular beam:

$$HD=\frac{1}{\Phi_1\Phi_2}\sqrt{\frac{\sqrt{(a_1^2\Phi_2^2+a_2^2\Phi_1^2)^2-4\Phi_1^2\Phi_2^2(a_1^2a_2^2-[\frac{G\cdot\Phi\cdot e^{-\mu r}}{MPE_7}]^2)}-(a_1^2\Phi_2^2+a_2^2\Phi_1^2)}{2}}$$

HD (skin, μ = 0) = _____

HD (skin, $\mu \neq 0$) = _____

(3) DIFFUSE REFLECTION HAZARDS (See ANSI Z136.1, B3.2.2/3, Examples 8 to 10)

Viewing distance (r_1) is generally 20 cm or greater from a diffuse reflector or extended source (most adults cannot focus closer than 20 cm.) r_1 (cm) = _____

α_{min} = (See ANSI Z136.1, Paragraph 8.1 and Table 6, Note 1) _____

Beam Diameter (D_L or D_ρ) of extended source or laser beam at diffuse surface, D_L or D_ρ (cm) = _____

$\alpha = D_\rho / r_1$ = _____

C_E = (See ANSI Z136.1 Table 6) _____

$MPE_{EXT} = MPE_5 * C_E$ = _____

Diffusely reflected beam power, Φ_{EXT}, which does not exceed MPE_{EXT} at distance r_1:

(let $\rho_\lambda \cos\theta = 1$) $$\Phi_{EXT} = \frac{\pi \cdot MPE_{EXT} (r_1 + D_\rho/2)^2}{\rho_\lambda \cos\theta} =$$ _____

Diffuse reflection hazard at r_1: Is $\Phi > \Phi_{EXT}$? _____
If the answer is yes, then continue to compute diffuse hazard distance.

$$r^*_{1max} = \frac{D_L}{\alpha_{min}} =$$ _____

$$r^{**}_{1(safe)} = \sqrt{\frac{\rho_\lambda \cdot \Phi}{\pi \cdot MPE_5}} =$$ _____

If $r_{1(safe)} > r_{1(max)}$ then the hazard distance is $r_{NHZ1} = r_{1(safe)}$

$$r^{***}_{NHZ1}(\alpha < \alpha min,) = \sqrt{\frac{\rho_\lambda \cdot \Phi \cdot \cos\theta_v}{\pi \cdot MPE_5}} =$$ _____

If $r_{1(safe)} < r_{1(max)}$ then the hazard distance is r_{NHZ2}

$$r^{***}_{NHZ2}(\alpha min < \alpha < 0.1 rad) = \frac{\rho_\lambda \cdot \Phi \cdot \cos\theta_v}{\pi \cdot MPE_5 \cdot r_{1max}} =$$ _____

If $r_{NHZ2} < 10D_\rho$ then the hazard distance = $10D_\rho$

$$r^*_{NHZ}(Skin) = \sqrt{\frac{\rho_\lambda \cdot \Phi \cdot \cos\theta_v}{\pi \cdot MPE_7}} =$$ _____

$$r^{****}_{diffuse} = \frac{1}{\Phi}\sqrt{\frac{1.27\Phi}{\pi \cdot MPE_{EXT}} - D_L^2} =$$ _____

Notes

* r_{1max} = distance beyond which an extended source or diffuse reflector must be considered a point source.

** $r_{1(safe)}$ = safe viewer distance from diffuse reflector when beyond r_{1max}. Note that this is the same as r_{NHZ} for $\alpha < \alpha_{min}$ and $\cos\theta_v = 1$.

*** r_{NHZ} = minimum safe viewing distance for looking at a diffuse target with reflectivity ρ_λ at wavelength λ with a viewing

angle of θ_v from beam line of sight. This is also the border of the nominal hazard zone (NHZ).

**** $r_{(diffuse)}$ = distance of laser from diffuse reflector to prevent a hazardous diffuse reflection to an observer at a viewing distance less than 10 times the laser beam diameter (distance within which image brightness on the retina remains constant). To compute C_E correction factor for MPE_{EXT} assume that most adults will be 20 cm from the diffuse surface and estimate laser beam diameter on the diffuse surface from knowledge of the intended laser location. Diameter of beam waist and distance, r_0 , from the exit port to any beam waist formed in front of laser, must also be considered. NOTE: Since MPE_{EXT} is range dependent this equation cannot be solved in closed form. Iterative techniques are required.

SECTION IV: Multiwavelength Analysis

When several wavelengths of laser radiation are combined in one beam the combined ratios of each radiant exposure to each MPE, for each wavelength, shall not exceed one.

$$H_1/MPE_1 + H_2/MPE_2 + H_3/MPE_3 + \ldots H_N/MPE_N \leq 1 = \sum_{i=1}^{i=N} H_i/MPE_i$$

If we choose the worst case MPE_N and multiply the above by this factor and let $MPE_N/MPE_i = S_i$ then the NOHD equation becomes

$$NOHD = \left(\frac{1.27 e^{-\mu r}}{MPE_N} \cdot \Sigma \frac{S_i Q_i - a_i^2}{\phi_i^2} \right)^{\frac{1}{2}}$$

SECTION V: Components and Hazards

Hazardous Substance Identification: Description/Notes:

SECTION VI: Special Protection Information

(1) Describe Energy source(s) - (Electrical ___Volts?, chemical, X-radiation, flashlamp, laser pump, laser oscillator, laser amplifier, etc.):

Electrical:

Respiratory:

Others:

SECTION VII. Installation Survey Results (For Military Ranges refer to MIL-HDBK-828)

a. Buffer Zones. Identify buffer zones where applicable. Buffer zone either side of laser beam shall be 5 times the aiming accuracy in milliradians. Normally stabilized platforms will give the following buffers:

Stabilized ground based, tripod mounted, aircraft mounted, shipboard mounted lasers - 5 milliradians
Handheld lasers - 10 milliradians
Unknown stabilization (night time unlighted reticle) - 15 milliradians

Unless stabilized in all axes, assume 15 milliradian buffers.

b. Nominal Hazard Zone (NHZ). Describe the NHZ of the laser. NHZ includes direct beam or specularly reflected beam out to NOHD or back stop, hazardous diffuse reflection area, and buffer zone around all radiation.

c. Controlled Areas. Include methods of control, signals, backstops, removal of specular reflectors, interlocks, restricted access, TV or radar surveillance, etc.

d. Safety Procedures. Include training, supervisory controls, means of communication, written procedures, and specifications and operational procedures for the use and care of protective eyewear.

e. Medical Surveillance. Indicate personnel names, identity of laser and incidental workers, types of lasers with which they work, locations.

f. Associated Hazards Control. Identify other laser system hazards and controls: Electrical, chemical, cyrogenic, etc., during operation, maintenance, storage, transport, or disposal.

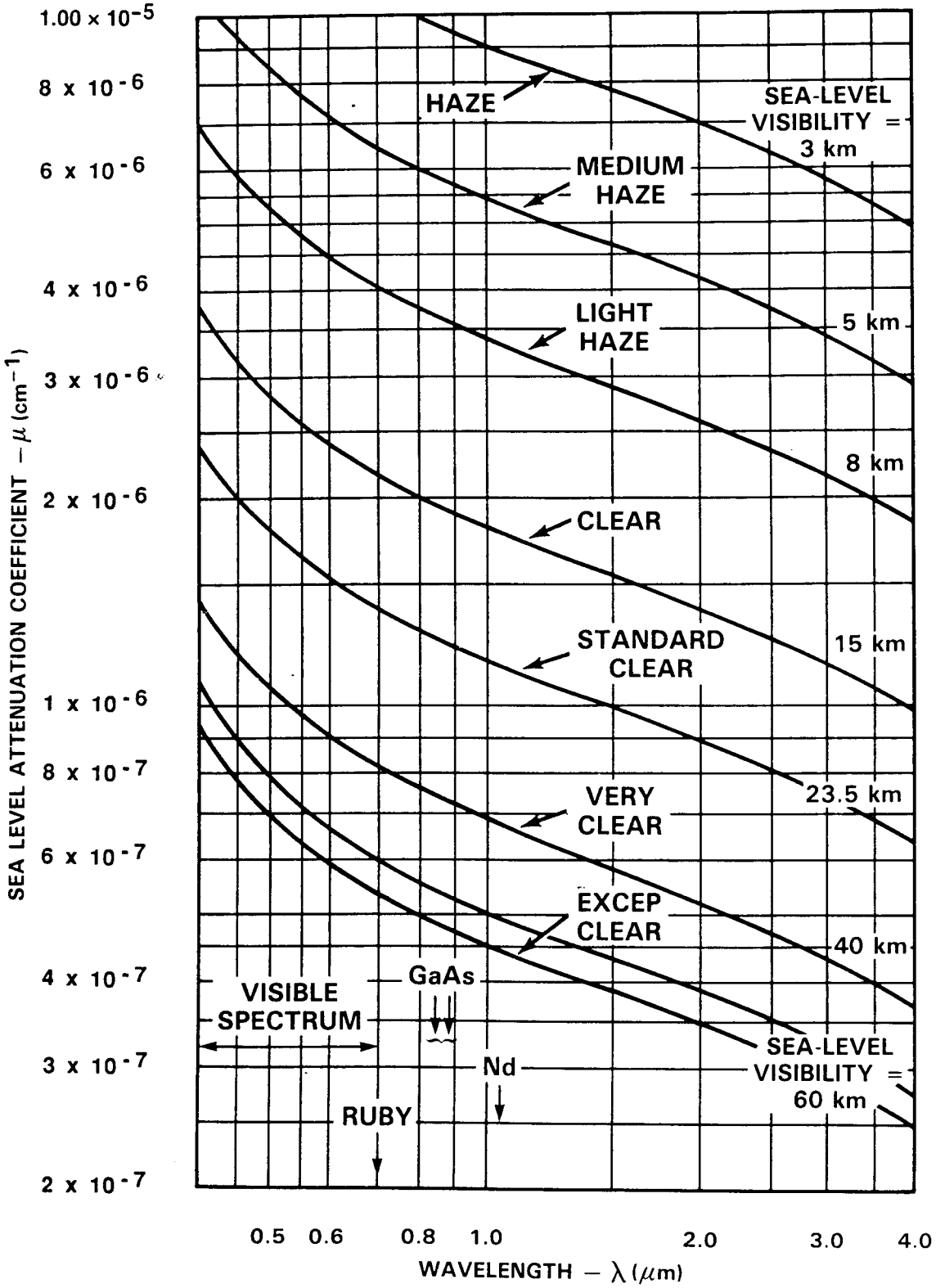


Figure 5-1. Approximate Atmospheric Attenuation Coefficient at Sea Level as a Function of Laser Wavelength and Meteorological Visibility. (Absorption by water vapor and carbon dioxide is neglected.)

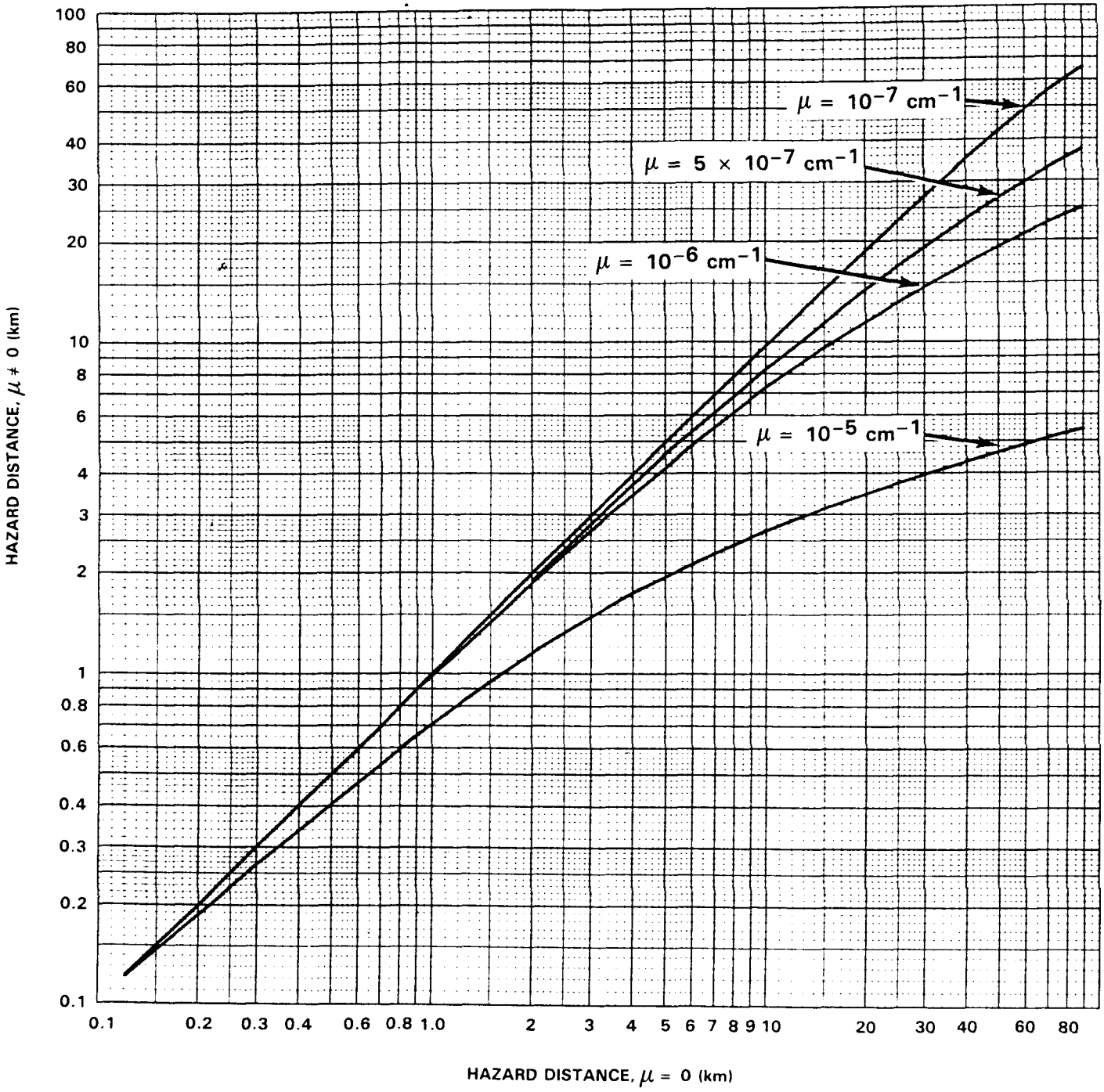


Figure 5-2. Hazard Distance ($\mu \neq 0$) versus Hazard Distance ($\mu = 0$), on a Scale from 0 to 100 km.

Enclosure (5)

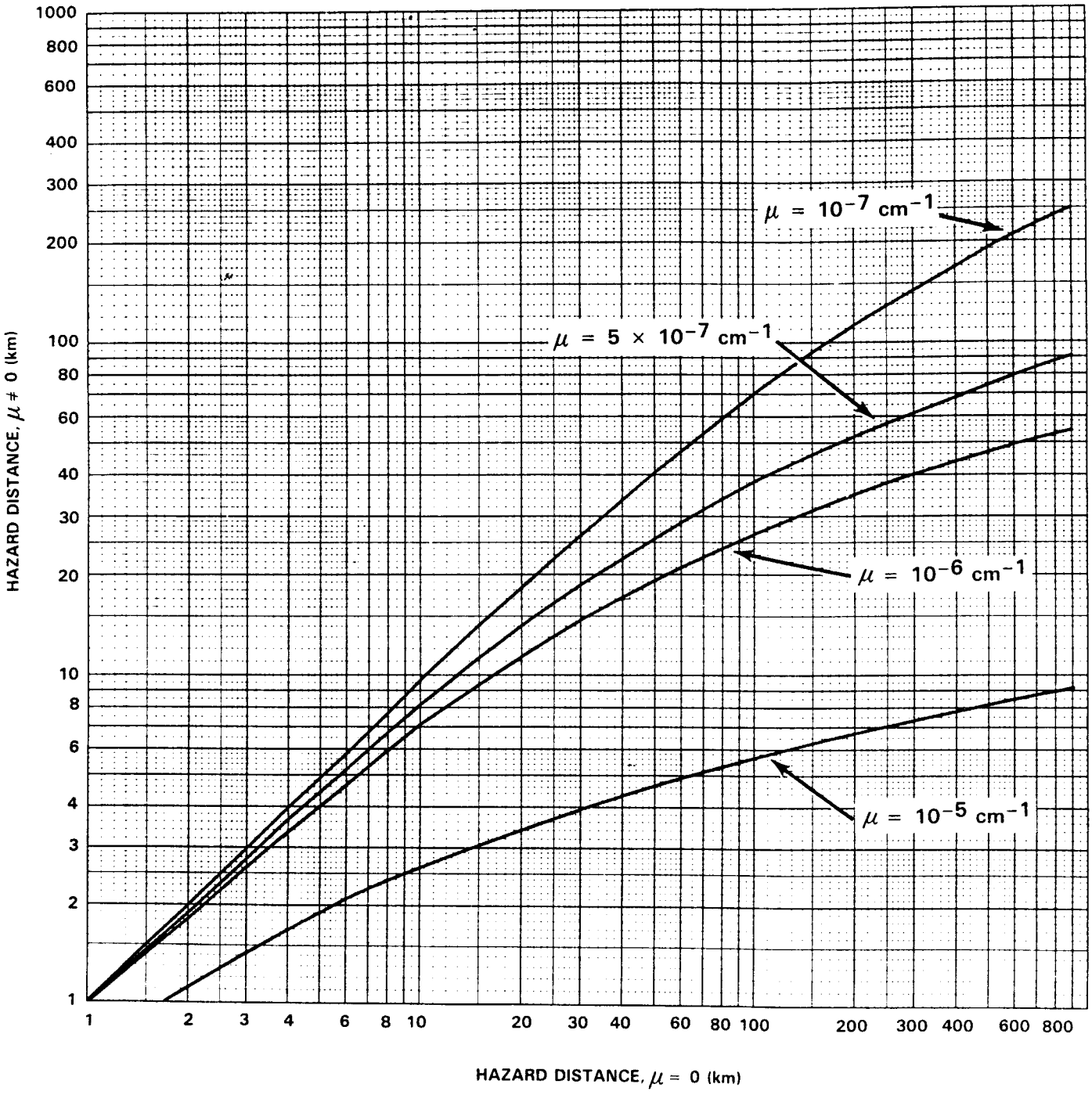


Figure 5-3. Hazard Distance ($\mu \neq 0$) versus Hazard Distance ($\mu = 0$) on a Scale from 0 to 1000 km.

Enclosure (5)

Table 5-1. ABSORPTION COEFFICIENTS (μ) PER CENTIMETER OF PURE WATER

WAVE-LENGTH (λ)	ABSORP COEFF cm^{-1}	WAVE-LENGTH (λ)	ABSORP COEFF cm^{-1}	WAVE-LENGTH (λ)	ABSORP COEFF cm^{-1}	WAVE-LENGTH (λ)	ABSORP COEFF cm^{-1}
320 nm	0.0058	520 nm	0.00019	850 nm	0.0412	1600 nm	8.00
340 nm	0.0038	540 nm	0.00024	900 nm	0.0655	1700 nm	7.30
360 nm	0.0028	560 nm	0.00030	950 nm	0.2880	1800 nm	17.0
380 nm	0.00148	580 nm	0.00055	1000 nm	0.3970	1900 nm	73.0
400 nm	0.00072	600 nm	0.00125	1050 nm	0.1770	2000 nm	85.0
420 nm	0.00041	620 nm	0.00178	1100 nm	0.2030	2100 nm	39.0
440 nm	0.00023	650 nm	0.00210	1200 nm	1.232	2200 nm	21.0
460 nm	0.00015	700 nm	0.0084	1300 nm	1.500	2300 nm	24.0
480 nm	0.00015	750 nm	0.0272	1400 nm	16.0	2400 nm	42.0
500 nm	0.00016	800 nm	0.0240	1500 nm	19.4	2500 nm	85.0

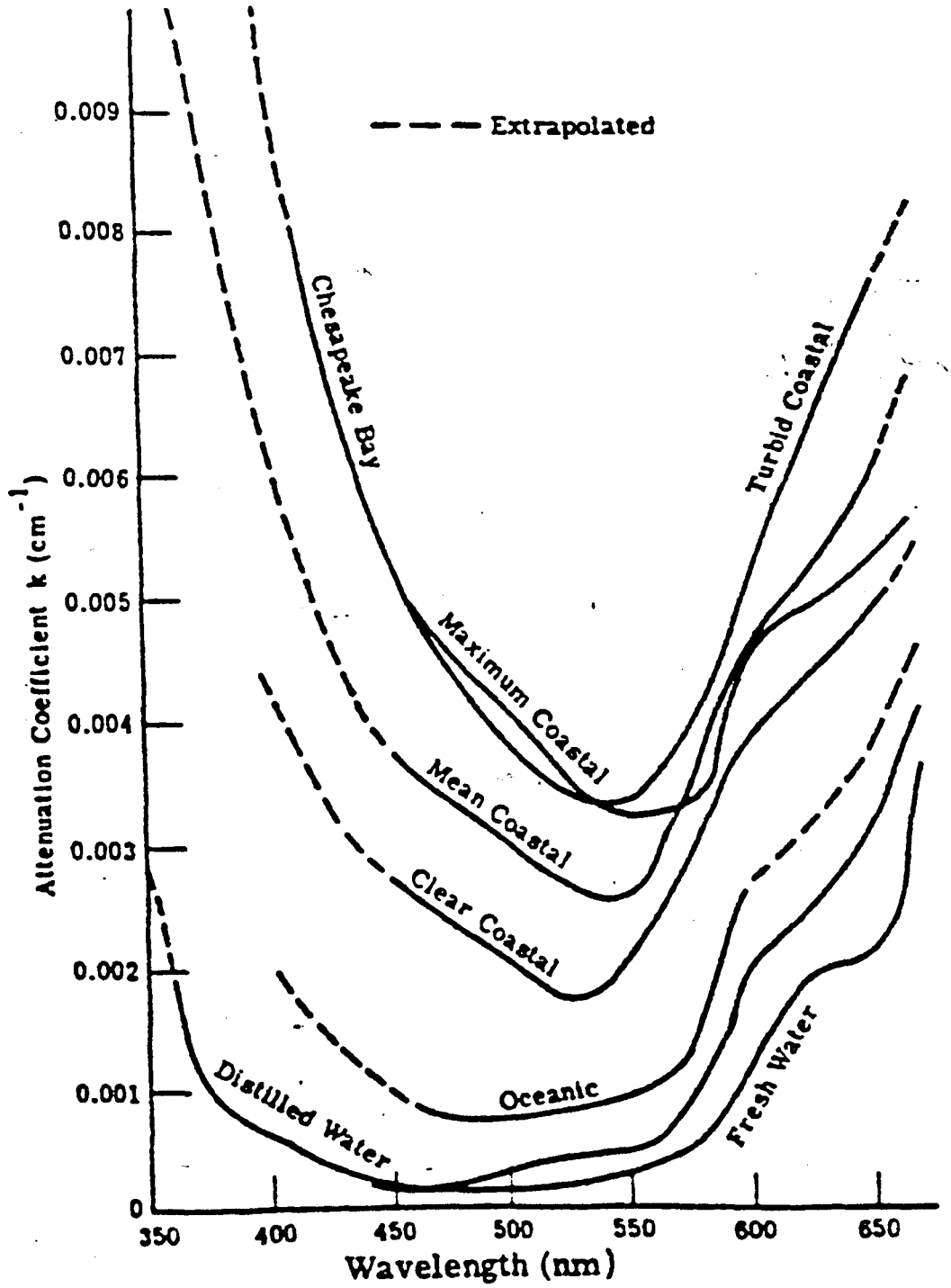


Figure 5-4. Attenuation coefficient versus wavelength for various water conditions.

EYE PROTECTION REVIEW REQUEST FORM

Classification _____ Date _____

Project Title _____

Project Officer _____

Address _____

_____

_____

_____

Type of Laser _____ Wavelength _____

Duration of Output _____ seconds (Enter CW if longer than 1 sec.)

Pulse Repetition Frequency _____ pulses per second (if other than CW.)

Beam Cross Section: Circular ___ Elliptical ___ Rectangular ___

Other ___.

Beam Diameter (1/e points) _____ centimeters

Beam Divergence _____ milliradians

Peak Power _____ watts

Energy Per Pulse _____ joules

Maximum exposure duration per 8 hour working day:

_____ hours _____ minutes _____ seconds

Minimum distance in meters between laser and following personnel:

____ ship _____ ground _____ airborne ____ shop

ACTIVITY LASER HAZARD CONTROL PROGRAM

1. A formal hazard control program is not required for class 1, 2 and 3a lasers and for optical fiber communication systems using lasers which comply with the design and operational procedures of ANSI Z136.2. (NOTE: Activities shall especially caution individuals using class 3a lasers labelled with a danger logo that these devices should be handled as if they were class 3b lasers capable of causing severe eye damage). All activities, including medical facilities, which use class 3b or class 4 lasers or systems incorporating any class 3b or class 4 lasers, shall establish a formal laser hazard control program. The program will include as a minimum:

a. Regulations. Establish an appropriate laser safety organization and promulgate laser safety regulations and standard operating procedures for indoor and outdoor operations and maintenance.

b. Laser System Safety Officer (LSSO). The commanding officer shall designate an individual by name and code as the LSSO. Responsibilities and duties of the LSSO shall be formally documented to ensure that lasers are operated safely in accordance with this instruction. The LSSO shall have direct access to the commanding officer and have the authority to suspend, restrict, or terminate the operation of a laser or laser system. The LSSO shall be trained and qualified to perform their duties as either a Category I (Technical and Management qualified) or Category II (Management qualified only) LSSO in accordance with enclosure (8). Refresher training shall be obtained periodically if technical training is not used within one year of completing a SPAWAR approved LSSO training course.

c. Laser Classification and Labeling. Each laser shall receive LSSO safety approval and be classified and labeled prior to use according to enclosure (10). Class 3b and class 4 lasers include those which operationally may be class 1 or class 2 lasers, but when broken down for maintenance allow class 3b or class 4 radiation levels to be accessible. For example, if radiation at the level of class 3b or class 4 is accessible when a class 1 laser housing is removed, then procedures and labeling of the laser and maintenance manuals must warn of this condition.

d. Protective Equipment. Appropriate laser protective equipment i.e., eyewear, clothing, barriers, screens, etc., shall be provided to employees. Laser eye protection shall provide optical densities, at the operating wavelength(s), under both unaided and optically aided viewing to ensure that the applicable Maximum Permissible Exposure (MPE) is not exceeded. Eyewear shall be labelled with the wavelength and optical densities and inspected periodically to ensure its integrity. Any degradation such as cracks or bleaching shall result in replacement. Notify all concerned personnel, including SPAWAR (00F) of any defective eyewear. See enclosure (8) for further guidance.

e. Safety Inspections and Surveys. Local laser facilities and ranges shall receive safety compliance inspections at least annually. Laser radiation hazard surveys and evaluations shall be performed on laser ranges to determine the degree of laser radiation hazard and to recommend proper controls. These hazard surveys and evaluations shall be repeated whenever changes occur or at least every three years. Training qualifications for personnel conducting inspections and surveys are described in enclosure (8). Hazard surveys and evaluations will determine if buffer zones on ranges are adequate, areas where specular reflectors must be removed, and whether beam stops are adequate to limit beam travel. Upon completion of the hazard

surveys the range LSSO will recommend conditions under which the activity Commanding Officer may certify the safety of the range through instructions and standard operating procedures.

f. Medical Surveillance Program. Establish and maintain a laser medical surveillance program in accordance with NAVMEDCOMINST 6470.2A.

g. Laser Inventory. Maintain and submit to Commander, Space and Naval Warfare Systems Command (SPAWAR 00F) all necessary records required by SECNAVINST 5100.14B and other government regulations. Maintain a list of all lasers and their locations at the activity. Submit an annual laser inventory to COMSPAWARSYSCOM per paragraph 7e(6) of this instruction.

h. Warning Devices and Signs. Laser warning devices and signs shall be posted at appropriate locations to protect unsuspecting personnel from laser radiation in accordance with reference (b) and enclosures (8) through (10).

i. Documented Safety Duties for Laser Supervisors. The safety responsibilities of personnel who supervise laser operations shall be documented. Those duties include such functions as safety planning for the installation of laser systems, providing and enforcing operational procedures, ensuring employees receive appropriate training, investigating incidents, and logging laser firings per enclosure (9). The supervisor shall submit this information to the LSSO for approval or other actions as appropriate.

j. Operator Training and Certification. A command laser safety training program shall be conducted in accordance with ANSI Z136.1-1993. Prior to assignment, employees who work with lasers shall receive formal classroom training in methods of hazard control per enclosure (8). Procedures to qualify as a laser operator or maintenance technician worker shall be established. Procedures shall include periodic review to ensure that personnel are complying with requirements such as annual refresher training. For construction workers, the requirement of reference (c) to have proof of their training readily available or in their possession applies.

k. Emergency Provisions. The emergency operating procedures or emergency shutdown procedures shall be posted at each laser installation in a location which is safely accessible to personnel rendering emergency aid. Emergency medical technicians and firefighters shall be trained in laser hazards and controls.

l. Laser Safety Committee. Establish a local laser safety committee to assist in discharging the above responsibilities if warranted by the magnitude of the potential hazards in local operations.

m. Laser Mishap Investigation and Reporting. Ensure prompt medical attention is given to laser injuries. Investigate and report laser mishaps per OPNAVINST 5100.23C and NAVMEDCOMINST 6470.2A. Copies of reports shall be sent to the Naval Safety Center, BUMED (212) and SPAWAR 00F. Ensure corrective actions are taken to prevent similar mishaps.

n. Disposal of Military Exempt Lasers. Obtain SPAWAR 00F approval prior to disposal of military exempt lasers. Ensure excess military exempt lasers are not sold or donated outside DOD unless they have been brought into compliance with 21 CFR and received FDA registration.

GENERAL REQUIREMENTS FOR LASER HAZARD CONTROL

1. Introduction

a. The acronym "laser" is derived from the initial letters of the words "Light Amplification by Stimulated Emission of Radiation." Figure 8-1 of enclosure (8) illustrates the laser wavelength spectrum. The biological effects of laser radiation are similar to light generated by high intensity, conventional, ultraviolet, infrared, and visible light sources such as the sun, nuclear explosions, and arc lamps. The chance of eye or skin damage, however, is greater from laser radiation because the laser output is highly coherent (in phase), and the high intensity is localized into a very directional beam. Usually, when laser radiation is absorbed by the body or eyes, it is converted into heat which, in turn, causes redness, blistering, and, if intense enough, even charring of the skin or visual impairment which may be permanent.

2. General Precautions Applicable to All Ground Installations

a. Unprotected personnel shall never be exposed to laser radiation in excess of the maximum permissible exposure (MPE) levels in ANSI Z136.1. Typical MPEs are provided in Tables 8-1 and 8-2 of enclosure (8). The method of calculating safe distance for aided and unaided viewing is given in enclosure (5). It should be noted that safe viewing distance is significantly increased when using optically aided viewing devices.

b. Direct viewing of laser beams, even during optical alignment, is prohibited when levels are greater than MPE. Viewing through attentuating material that limits the radiation to levels below the MPE may be performed with permission of supervisory personnel. It should be noted that under these conditions plastic attenuating material may be less suitable than glass, since it may melt under much lower levels of radiation.

c. Optical systems such as lenses, telescopes, etc., will increase the hazard to the eye and may be used only when appropriate interlocks or filters are used to attenuate the radiation levels below the MPE.

d. All involved personnel shall be trained to avoid looking directly into an operating laser or its reflection. Personal protective equipment specifically designed and so marked for protection against the laser system shall be used when engineering or procedural controls are inadequate to eliminate radiation levels in excess of the MPE.

e. Laser protective eyewear shall be marked with optical density values and wavelength for which protection is afforded and issued to involved personnel. The eyewear shall provide a snug fit and shall not be used if it does not pass inspection. Before each use and during periodic LSSO safety inspections, laser eye protection shall be inspected. This will include:

(1) Inspection of the attentuator material for pitting, crazing, cracking, bleaching, etc.

(2) Inspection of the goggle frame for mechanical integrity and leaks.

f. Only authorized personnel shall operate laser systems.

g. Spectators shall not be allowed access to the laser control area unless appropriate supervisory approval has been obtained and protective measures taken.

h. At least two people should be present at all times when operating lasers where they are exposed to hazardous energy sources. This two person rule is primarily intended so that first aid may be rendered in event of an injury and to prevent access by unauthorized personnel. Where the operation allows, a countdown procedure should be followed to minimize unnecessary potential exposure by forewarning personnel to take necessary protection from the radiation by donning protective equipment or moving out of the danger area.

i. Reflecting surfaces which are not specifically approved for use in the exercise such as standing water, mirrors, bottles, windows, shiny metal, plexiglass or other surfaces which have a high coefficient of specular reflection shall be eliminated from the beam path or shall be faced and surrounded with diffuse absorbing substances to absorb the energy. Personnel working in the vicinity of laser beams shall not wear jewelry such as tie clasps which could act as specular reflectors. Some of the most serious eye injuries incurred from laser radiation to date resulted from reflections due to: (1) glass and other shiny surfaces such as tie clasps, (2) another person's protective eyewear, and (3) a class 4 laser beam reflected from a diffuse white backstop.

j. Lasers and laser beams should be contained within a suitably controlled equipment or space so that personnel in such an area cannot be accidentally injured. Laser beams emitted by an unenclosed system must be terminated at the end of the useful beam path if the exposure level is greater than the maximum allowable level. The backstop shall be of material that absorbs the particular wavelength and shall not burn or emit toxic products when irradiated. Special care in absorbing and containing the laser radiation must be taken especially when the laser is emitting energy in the ultraviolet or infrared portions of the spectrum where the observer might receive damage to the eyes without being aware of the direct radiation or its reflection. Laser controls must be located to prevent operator exposure to unsafe levels of radiation. Care should be taken to block all extraneous radiation such as that reflected or refracted from materials used to interact with laser beams.

k. Laser range and building warning signs as shown in Figures 9-1 and 9-2 of enclosure (9) shall be posted at the entrances to laser ranges and buildings.

l. Provision shall be made to protect against hazardous by-products which may result from the reaction of laser radiation, especially untraviolet laser radiation, with air and other substances such as ozone and skin irritating agents.

m. Other hazards in laser installations may arise from the following:

(1) Electricity

(2) Cryogenics

(3) Compressed gas

(4) Toxic material

(5) Noise

(6) Arc of filament lamps

(7) Targets which may shatter

(8) Ionizing radiation

(9) Incoherent optical and ultraviolet radiation from laser discharge tubes, flash lamps or laser/target plasmas

(10) Charged capacitors

(11) Flash lamp or capacitor explosion

Appropriate precautions shall be taken in accordance with standard Navy safety practices.

n. Proper personnel protection and procedures shall be provided in the use of cryogenics. Compressed gas bottles shall be secured. All laser discharge tubes or flash lamps, the laser target, capacitors, and all elements of the optical training which may shatter shall be adequately contained. All voltages in excess of 30 volts shall be guarded. All incidental radiation shall be adequately shielded. Toxic materials shall be so marked and adequately controlled. Smoking, eating, or drinking in laser work areas shall be prohibited.

o. Prior to laser operations, the operator shall ensure that the laser target area and laser hazard zone is clear of personnel or that any personnel within the area are aware of imminent laser operation and are properly protected against laser hazards.

3. General Precautions Applicable to Air, Sea and Military Ground Laser Operations

a. Planning

Lasers shall not be used in airborne, at sea or military ground operations unless they have been approved by the Navy Laser Safety Review Board (LSRB). Safe distances and recommended eye protection will be established by the LSRB for each system. Operational safety requirements for the specific system will be developed by the cognizant operational command using the safety data provided by the program manager and approved by the LSRB. In developing operational safety requirements, the following information shall be utilized:

(1) Because of its broad band absorption, most current laser protective eyewear may reduce night time visibility and impair visibility of indicator lights. Hence the use of aviator's protective eyewear is recommended only for the short time when required during laser operation. Use one-half the single pulse nominal ocular hazard distance (NOHD) of the system as the hazard distance from reflectors when laser eye protection is required. Use the single pulse NOHD as the safe distance from aircraft transiting your path. Use the multipulse NOHD as the safe distance for any personnel at the target area. NOHDs, buffer zones, and approved protective eyewear for specific systems are provided in E0410-BA-GYD-010 Laser, Technical Manual, Laser Safety, available from the Aviation Supply Office, Naval Publications and Forms Directorate, 5801 Tabor Ave., Philadelphia, PA 19120. For systems not listed in the Technical Manual on Laser Safety, contact SPAWAR 00F for additional information.

(2) Laser protective eyewear may also be useful in overcoming the dazzling effect of nonhazardous laser radiation.

b. Precautions

(1) During airborne laser operations, personnel in the lasing aircraft must wear laser protective eyewear in single aircraft laser scenarios if there is a possibility of retroreflectors or other flat specular reflectors in the target area and within one-half the NOHD.

(2) All personnel in other aircraft which must fly in the restricted airspace through a defined laser hazard area must have suitable laser protective eyewear in place during transit of that hazard area. All personnel in other aircraft in the restricted air space within a cone at an angle from the laser beam equal to 20 times the buffer zone angle shall wear protective eyewear. For example, if the buffer zone for a laser is 5 milliradians, aircraft within 100 milliradians or 5 degrees of the laser beam out to the nominal ocular hazard distance shall have aircrew eye protection in place for that laser.

(3) During actual combat, aircrews should be supplied with, but not be required to use, protective eyewear for the reasons stated in paragraph 3a of this enclosure. With improvements in future laser eye protection this direction may change.

(4) All topside personnel on ships or on the ground who may be in a defined laser hazard area must wear suitable laser protective eyewear during laser operations. Follow precautions in MIL-HDBK-828 and E0410-BA-GYD/010 Laser Safety Technical Manual.

4. Laser, Associated Support Equipment, and Facilities Design Safety Features

a. All non-exempt lasers must be designed and built according to 21 CFR Part 1040. Associated support equipment, facilities, protective eyewear, and operating and maintenance procedures shall be in accordance with ANSI Z136.1, manufacturer instructions, and Laser Safety Review Board (LSRB) requirements where applicable. All optical fiber communication systems shall include the requirements of ANSI Z136.2. All military exempt lasers, their associated support equipment, facilities, and eye protection shall be designed and constructed in accordance with MIL-STD-1425A. Operating and maintenance procedures for military exempt lasers shall include those approved by the LSRB.

b. Among its many safety features, each laser, regardless of class, must have protective housings to prevent excessive optical and X radiation. All laser protective housing must be interlocked. When the protective housing containing the laser beam is not interlocked or has defeatable interlocks, a warning sign must be provided stating "Caution or Danger" with additional information concerning the hazard involved.

c. Other laser safety requirements include an emission indicator which provides a visible signal when viewed through protective goggles, or an audible warning signal during laser radiation emission in excess of the maximum allowable safe limits. The warning signal must not cause personnel to inadvertently look into the laser beam or reflected radiation from the target. Personnel should be made aware of the meaning of this emission indicator. Each class 3b or class 4 laser must be supplied with a beam attenuator capable of preventing unsafe levels of laser radiation. This attenuator shall be used whenever possible especially during maintenance. Class 3b and class 4 laser area access must be interlocked with the laser system to prevent accidental

radiation of unsuspecting personnel. Where this is not feasible, a nominal hazard zone (NHZ) may be defined and enforced instead of interlocking entrances to general laser work areas. The use of electric eyes and warning alarms is recommended to assist in policing the perimeter of the NHZ.

d. To reduce the hazard distance when radiation may be reflected from protective eyewear over long distances, use protective eyewear with curved surfaces and high absorption at the laser wavelength whenever feasible.

e. Safety procedures shall be posted outside each entrance to the area where lasers are operated or maintained. They shall address, where feasible, each laser used therein by name and shall include:

(1) Lasers authorized.

(2) Normal operations.

(3) Entry restrictions.

(4) Types of protective eyewear required (wavelength and optical density).

(5) Startup safety requirements (types and locations of beam stops, countdown procedures, area clearance procedures, warning lights activated outside and inside the area, etc.).

(6) Emergency shutdown procedures for fire, rescue, and security personnel in case of emergency.

(7) Conditions for unattended operation if permitted by the LSSO.

(8) Exact hazardous material allowed and conditions of permitted use, including personal protective equipment, fire fighting equipment, ventilation requirements, storage containers, allowed amounts, and emergency response procedures.

(9) Specific prohibitions, e.g., no smoking or flames, no eating or drinking.

(10) Requirement for two personnel to be present during operations, for emergency assistance where deemed necessary by the LSSO.

f. Laser boresight alignment and retention shall be designed consistent with system mission requirements and shall be considered a safety-critical item. All laser systems used in combat, combat training, or used on ranges must have boresight verification at least quarterly, be verified to specifications when in intermediate maintenance, and be verified as determined appropriate by the LSSO or to specifications when verified during intermediate or depot level maintenance.

5. Training

a. All personnel in areas using class 3b or class 4 lasers shall be informed by formal classroom training about the potential hazard associated with accidental exposure to this form of radiation. Additionally, since many laser pointers used in briefings and laser leveling devices are class 3a with a danger logo, provide widespread dissemination of information concerning the eye injury potential of these lasers. In particular, the extraordinary danger of eye damage due to focusing and absorption by this organ shall be emphasized. Class 3b and class 4 lasers may also cause skin damage or damage

to material by fire or explosion due to rapid heating from a focused beam. Training shall include actual demonstrations of the destructive capability of the laser (by video or other non-hazardous method of training) and the procedure for calculating maximum permissible exposure levels. Annual refresher safety training appropriate to the operation shall be conducted. Topics for refresher safety training should be at the discretion of the supervisor in conjunction with the LSSO and may consist of information interchange seminars between laser users on the usefulness of existing safety procedures, information on recently discovered hazards/hazardous materials or suggestions for new safety devices. Initial safety training should be a minimum of four to eight hours. Typical topics for initial training include:

(1) What is a laser and what are the hazards associated with each part, hazards from pump sources, optical cavity materials, electro-optic cells for such materials as dyes, solvents or crystals, mechanically moving parts, lasing medium, radiation (direct or collateral laser, X-ray, light, RF, or noise radiation), coolants, compressed gases, products of reactions, fires from flammable targets, specular and diffuse reflections, etc.

(2) Type of hazards specific to the system(s) in use or under maintenance. Discuss types of hazards (hazard due to direct beam or specular or diffuse reflections) in the various areas such as target, operator, observer, and maintenance areas. Discuss the specific controls instituted to protect each area, (engineering controls, protective equipment, administrative controls, specific procedures to avoid laser hazards, alarms, types of signs to be posted, etc.)

(3) Type of eye protection to be worn (when and where, appropriate optical density at the proper wavelength, hazardous reflections from eyewear, damage thresholds, inspection and maintenance) and any other personal protective equipment required.

(4) Manufacturer's operating and safety information and any other safety requirements or procedures specific to the system(s).

(5) Medical surveillance requirements in accordance with BUMEDINST 6470.2 series.

(6) Thorough briefing on the standard operating procedures (SOPs) for each laser operation, with a written SOP given to each employee. If range personnel are being trained, emphasis should be given to the following:

(a) Two-way communications with all involved ships, aircraft, and shore personnel shall be established before laser operations commence.

(b) Acquisition, identification and tracking of the specifically assigned target shall be established prior to laser activation.

(c) No lasing shall occur until cleared by the range controller.

(d) Lasing shall cease immediately whenever the laser is not pointed in the immediate vicinity of assigned targets or the range controller terminates the run.

b. Laser System Safety Officer (LSSO). There are two categories of LSSO's,Category I (CAT I) and Category II (CAT II). Commanding officers should determine which category of LSSO is appropriate for their activity considering their mission, types of lasers being used, and size of the laser safety program. LSSO Categories and qualifications are as follows: (R)

(1) Category (CAT) I LSSO - Must have successfully completed the CAT I Laser Safety course taught by the Naval Safety School with a grade of at least 90 percent on the technical and 80 percent on the management portions of the final exam. A CAT I LSSO is qualified to:

(a) Calculate or measure laser safety parameters such as Nominal Ocular Hazard Distances (NOHD) and required optical densities for laser eye wear.

(b) Train CAT II LSSO's (requires SPAWAR approval).

(c) Conduct laser radiation hazard surveys and evaluations for commanding officer certification, as required in this instruction, for specific laser use.

(d) Classify lasers and laser systems.

(e) Conduct technical aspects of laser incident investigations.

(f) Perform the same tasks as a CAT II LSSO.

(2) Category (CAT) II LSSO - Must have successfully completed the the Laser Safety management course taught by the Naval Safety School or a SPAWAR approved CAT II LSSO training course with a grade of 80 percent or better. A CAT II LSSO does not have the technical capability to calculate or measure laser safety parameters and cannot serve as an instructor of other LSSO's. A CAT II LSSO is qualified to:

(a) Approve, disapprove, or submit for safety approval to higher authority all local laser uses, both portable and fixed.

(b) Instruct employees and supervisors on the safe use of lasers as outlined in this enclosure.

(c) Supervise laser operations and maintenance.

(d) Conduct laser range safety compliance inspections.

(e) Manage laser incident investigations as appropriate.

(f) Maintain a laser medical surveillance program.

(g) Maintain an inventory of military exempt and class 3b and class 4 lasers.

(h) Post laser warning signs and devices.

(i) Ensure that laser operators have the appropriate knowledge to safely operate their specific lasers (supervisor safety briefs, factory training school, instructional materials, etc.)

(j) Provide safety briefs to Laser Range users.

c. The laser range safety officer, laser maintenance personnel, and industrial laser supervisors shall have satisfactorily completed a formal laser safety course which shall include as a minimum:

(1) Theory of lasers

(2) Laser hazards to: the eye, the skin, materials

(3) Associated hazards (electrical, cryogenic, chemical, mechanical),

(4) Reflections (specular and diffuse)

(5) Laser hazard categories

(6) Maximum permissible exposure (MPE)

(7) Nominal ocular hazard distance (NOHD)

(8) Eye protection program (wavelength and optical density (OD) of the various types of eyewear, hazardous reflections from eyewear, eyewear inspection and maintenance).

(9) Medical surveillance

(10) Records (firing log, etc.)

(11) Laser safety instructions (SECNAVINST 5100.14B, 21 CFR 1926.54 and 1926.102(b)(2), BUMEDINST 6470.2A, ANSI Z136.1, SPAWARINST 5100.12B, MIL-STD-1425,

(12) Laser range procedures (range safety officers)

(a) Briefing of mission commander or system user

(b) Description of targets and use of maps

(c) Communication procedures

(d) Lasing positions

(e) Ingress or egress routes (if applicable)

(11) Maintenance or operating instructions (maintenance and industrial supervisors)

(a) Review of test bench procedures/operating procedures.

(b) Review of all safety interlocks, warning lights, signs, etc.

(c) Review of system particular hazards

d. Laser safety training videotapes, "Laser Hazards and Control," 804245DN, and "Hazards and Control of Military Lasers," 804246DN, are available from the Naval Education and Training Support Centers. A training course, "Laser Safety Fundamentals," C-602-3770 CNTT(N4298D) is also available from the Naval Aviation Maintenance Training Groups(NAMTRAGRU).

e. Training should include safety information from reference (h) as appropriate for the use of military lasers.

5. Construction Lasers. In addition to the general rules, the following OSHA regulations of reference (c) must be applied to lasers used in construction:

a. Only qualified and trained employees shall be assigned to install, adjust, and operate laser equipment. They shall carry a card showing proof of

qualification.

b. Employees shall wear proper eye protection when there is a potential exposure to laser light greater than 0.005 watts (5 milliwatts).

c. Beam shutters or caps shall be used or the laser turned off when laser transmission is not actually required. When the laser is left unattended for a substantial period of time, such as during lunch hour, overnight, or at change of shifts, the laser shall be turned off.

d. Employees shall not be exposed to light intensities above:

(1) Direct staring - 1 microwatt per square centimeter.

(2) Incidental observing - 1 milliwatt per square centimeter.

(3) Diffused reflected light - 2.5 watts per square centimeter.

e. Employees shall not be exposed to microwave power densities in excess of those specified in OPNAVINST 5100.23C, chapter 22, part II, section B.

LASER TYPE	WAVELENGTH (Nanometers)
Argon Fluoride	193 (UV)
Xenon Chloride	308 (UV) and 459
Xenon Fluoride	353 (UV) and 459
Helium Cadmium	325 - 442
Rhodamine 6G	450 - 650
Copper Vapor	511 and 578
Argon	457 - 528 (514.5 (green) and 488 (blue) most used)
Frequency doubled Nd:YAG	532
Helium Neon	543 (green), 594 (yellow), 612 (orange), 632.8 (red)
Krypton	337.5 - 799.3 (647.1 - 676.4 most used)
Ruby	694.3
Laser Diodes	630 - 950
Ti:Sapphire	690 - 960
Alexandrite	720 - 780
Nd:YAG	1064
Hydgrogen Fluoride	2600 - 3000
Erbium:Glass	1540
Carbon Monoxide	5000 - 6000
Carbon Dioxide	10600

Figure 8-1. Laser Wavelength Spectrum

Table 8-1. Typical CW Laser Intrabeam MPEs for the Eye and Skin

Laser	Wavelength (nm)	Maximum Permissible Exposure Eye	Skin
Argon	275	3×10^{-3} J/cm^2 (10 to 30,000 sec) (0.3 mw/cm^2 for 10 sec to 0.1 x 10^{-6}W/cm^2 for 30,000 sec)	3×10^{-3} J/cm^2 (10 to 30,000 sec)
Helium-Cadmium	325	1 J/cm^2 for 10 to 1000 sec (100 mw/cm^2 for 10 sec to 1 mw/cm^2 for 1000 sec)	1 J/cm^2 for 10 to 1000sec
Nitrogen	337.1	1 J/cm^2 for 10 to 1000sec (same as MPE at 325 nm)	1 mW/cm^2 for t > 1000sec
Helium-Cadmium	441.6	2.5 mW/cm^2 for 0.25sec	0.2 W/cm^2 for t > 10sec
Argon	488; 514.5	10 mJ/cm^2 for 10-10^4sec (1mw/cm^2 for 10 sec to 1 x 10^{-6}W/cm^2 for 10^4 sec) 1 x 10^{-6} W/cm^2 for t > 10^4sec	0.2 W/cm^2 for t > 10sec
Helium-Neon	632.8	2.5 mW/cm^2 for 0.25sec 1mw/cm^2 for 10sec 170 mJ/cm^2 for t > 453sec to 10^4 sec (0.375 mw/cm^2 for 453 sec to 17 x 10^{-6}W/cm^2 for 10^4sec) 17 x 10^{-6}W/cm^2 for t > 10^4sec	0.2 W/cm^2 for t > 10sec
Krypton	647	2.5 mW/cm^2 for 0.25sec 1 mw/cm^2 for 10sec 280 mJ/cm^2 for t > 871sec (0.618 mw/cm^2 for 871 sec to 28 x 10^{-6} W/cm^2 for 10^4 sec) 28 x 10^{-6} W/cm^2 for t > 10^4sec	0.2 W/cm^2 for t > 10sec
InGaAlP	670	2.5 mw/cm^2 for 0.25 sec 320 x 10^{-6} W/cm^2 for 1000 sec	0.2 W/cm^2 for t > 10sec
Gallium Arsenide	905	0.8 mW/cm^2 for 10^3 to 10^4 sec	0.5 W/cm^2 for t > 10sec
Neodymium:YAG	1064	1.6 mW/cm^2 for t > 1000sec	1.0 W/cm^2 for t > 10sec
Carbon Dioxide (and other lasers 1.4-1000mm)	10600	0.1 W/cm^2 for t > 10sec	*0.1 W/cm^2 for t > 10sec

* Skin MPE: a) if beam size is 100 cm^2 to 1000 cm^2, MPE = 10000/A_s in mW/cm^2, where A_s is the area of the beam upon skin
b) if beam size exceeds 1000 cm^2, MPE = 10 mW/cm^2

Table 8-2

Typical Intrabeam MPEs for Pulsed Lasers

Laser	Wavelength (nm)	Pulse Duration(s)	PRF (pps)	MPE per Pulse (J/cm^2) Eye (at cornea)	Skin
The following MPE's assume a one sec. exposure for eye and 10 sec. for skin					
Argon	488	10^{-9} - 10^{-5}	1	5.0×10^{-7}	0.01
Nd:YAG	532	10^{-3}	1	1.0×10^{-5}	0.14
Nd:YAG	532	10^{-9} - 10^{-7}	1	5.0×10^{-7}	0.01
Ruby	693.4	10^{-9} - 10^{-7}	1	5.0×10^{-7}	0.01
			10	2.8×10^{-7}	6.0×10^{-3}
			20	2.3×10^{-7}	5.3×10^{-3}
			100	1.6×10^{-7}	2.0×10^{-3}
			1000	8.9×10^{-8}	2.0×10^{-4}
The following MPE's are for a single pulse exposure.					
Argon	488	10^{-9} - 10^{-5}		5.0×10^{-7}	0.02
Nd:YAG	532	10^{-3}		1.0×10^{-5}	0.20
Nd:YAG	532	10^{-9} - 10^{-7}		5.0×10^{-7}	0.02
Ruby	693.4	10^{-9} - 10^{-7}		5.0×10^{-7}	0.02
ND:YAG	1064	10^{-9} - 10^{-7}		5.0×10^{-6}	0.10
GaAs	905	10^{-9} - 10^{-7}		1.25×10^{-6}	5.0×10^{-2}
The following MPE's assume a 10 second exposure.					
Nd:YAG	1064	10^{-9} - 10^{-7}	1	2.8×10^{-6}	0.056
			10	1.6×10^{-6}	0.03
			20	1.3×10^{-6}	0.026
			100	8.9×10^{-7}	0.01*
			1000	5.0×10^{-7}	0.001*
					* (1.0 w/cm^2) for a 10s exposure)
GaAs	905	10^{-9} - 10^{-7}	1	0.7×10^{-6}	2.8×10^{-2}
			10	4.0×10^{-7}	1.58×10^{-2}
			100	2.2×10^{-7}	5.0×10^{-3}
Rhodamine 6G dye	About 500-700	0.5×10^{-6} to 20×10^{-6}	1	5.0×10^{-7}	0.03 to 0.07

SPECIFIC SAFETY PROCEDURES FOR MILITARY AND INDUSTRIAL LASER RANGES AND MAINTENANCE AREAS

CLASS 3b AND 4 LASERS

1. Operational Controls. Follow the general operational controls and training requirements of enclosure (8) and for military laser ranges follow MIL-HDBK-828. All lasers will be treated as if they were guns so that the same hazard control precautions will apply. Instructions shall be provided as follows:

a. Describe the hazard (safe distance, etc.)
(1) To eyes
(2) To skin
(3) To material

b. Post warning signs and barricades.
Note: For ranges where an outer fence adequately prevents unauthorized entry, no laser warning sign is required on the outer fence. Interior to the fenced area, however, the laser range shall be marked with signs such as those shown in figures 9-1 and 9-2 the area shall be blocked off.

c. Describe all laser safety interlocks which may affect or suspend laser firing.

d. Provide charts showing permissible lasing areas and the resultant hazard areas for each target and test range.

e. Conduct a laser range safety evaluation. The evaluation shall be conducted by personnel trained and qualified to recognize reflectors on Navy ranges such as glass, standing water, plexiglass or highly polished flat surfaces. Determine reflectance of all known specular targets and provide a chart of reflected radiation hazard information concerning those targets. Unless otherwise approved by the local laser system safety officer (LSSO) for test purposes, only targets which are diffuse reflectors shall be used. Portions of a diffuse target which are specular shall be rendered diffuse.

f. Provide a list of all required eye and skin protective devices for personnel downrange near the target and for flight, ship, or vehicle crews in lasing craft and other craft on land, sea, and air. Also provide a list of required eye and skin protection for maintenance personnel. All listed protection shall be provided prior to laser use. This shall include proper protection for optically aided devices such as binoculars. All eye protection shall be marked for the optical density and wavelength.

g. Provide clear means of communication (e.g., specific frequency on specific radios with specific procedures) to all affected personnel.

h. Laser range firings shall be rigidly scheduled and logged by the range for each series of firings. A log is not required for lasers in industrial operations and research where tracking for safety purposes serves no useful purpose. However operations shall be logged where exposure of unsuspecting personnel may be open to future questioning or where it is deemed necessary by the local LSSO for increased consciousness of the dangers involved. Figure 9-3 is provided to assist in developing forms for laser firings. Logs where required shall be kept on file per Navy regulations for retention of health records.

i. Aircraft shall make a clearing fly-by pass to ensure target areas and surroundings are clear of unauthorized personnel.

j. Lasers will not be activated until a designated target has been acquired optically or through a recognized tracking system (e.g., FLIR or radar).

k. Only the specific run-in headings designated for each target in the range safety evaluation shall be used while lasing.

l. Class 3 and class 4 lasers shall not be directed above the horizon unless coordinated with those responsible for the given airspace (Federal Aviation Administration, Navy, Air Force, U.S. Space Command, etc.)

m. Range Procedures

(1) Specific knowledgeable individuals shall be designated as range laser safety officers. No laser shall be fired without their approval. They may stop a laser firing at any time.

(2) Range test plans shall specify:

(a) Permissible aircraft flight path and ship or vehicle heading while lasing.

(b) Hazard areas to be cleared of non-operating personnel (roadblock locations, if required).

(c) Operational personnel locations (indicating those requiring eye protection devices).

(d) Types of surveillance to be used to ensure a clear range.

(e) Radio frequencies for communication where appropriate.

(3) Beam Termination. During laser operations, no portion of the laser beam may extend beyond the controlled target area, unless adequate surveillance can prevent radiation of unprotected areas. This will be accomplished by construction of the target or choosing a natural target the size of which will intercept the laser beam and provide an additional buffer zone as described in MIL-HDBK-828. This buffer zone is to be dependent on aiming accuracy, platform stability, target type (stationary or moving), target speed, terrain, maximum slew-rate in the event the system breaks lock (if so equipped), and operator response time. Buffer zones for specific systems are given in references (h) and (n).

(4) Ground laser operators who are designating targets for laser guided munitions shall be provided a means to determine whether they are radiating nearby foliage which may cause munitions to home in on their position rather than the target. Similarly, weapons launch vehicle software and hardware shall be designated to prevent the launching of munitions toward the laser operator, whenever possible.

2. Training. All laser system safety officers, ship crews, flight crews, target area personnel, maintenance personnel, laser operators, or others who may be exposed to hazardous levels of laser radiation, shall receive formal classroom training in both general laser radiation hazards and the hazards of the specific equipment used. Training shall include:

a. Type of eye protection to be worn (when and where, curved surface to rapidly diverge reflected beams from the front surface so that hazardous reflections from the eyewear are kept in the target area, appropriate optical density for appropriate wavelength, and proper periodic inspection).

b. Potential hazards in the target area, maintenance area, etc., types of warning signs to be posted, and specific procedures to avoid these hazards.

c. Thorough briefing on all range procedures with specific emphasis to ensure that:

(1) Two way communications with all involved ships, aircraft, general personnel, etc., are established before laser operations commence.

(2) Acquisition, identification, and tracking of the specifically assigned target are established prior to laser activation.

(3) No lasing occurs until cleared by the range controller.

(4) Lasing shall cease immediately whenever the laser is not pointed in the immediate vicinity of assigned targets or the range controller terminates the run.

3. Safety Requirements for Industrial Lasers. All lasers will be treated as intensive heat and light sources so that the same hazard control precautions will apply. Instructions shall be provided as follows:

a. Describe the hazards (safe distance, etc.)

(1) To eyes

(2) To skin

(3) To material

b. Post warning signs at entrances and interlocked barricades.

c. Describe as appropriate for operations or maintenance all laser safety interlocks which may affect or suspend laser operations.

d. Provide a floor plan showing permissible lasing areas and the resultant nominal hazard zone (NHZ) for each laser device during operation and during maintenance.

e. Determine reflectance of all known target materials and provide a chart of reflected radiation hazards information concerning those materials. Consult SPAWAR 00F for reflectance information.

f. Provide a list of all required eye and skin protective devices for the operator and other personnel required to be in the hazard area. Also provide a list of required eye and skin protection for maintenance personnel. This shall include proper protection for optically aided devices such as alignment devices. All eye protection shall be marked for the optical density and wavelength.

g. For lasers which are not completely enclosed and can emit radiation levels above the MPE, strict scheduling, written operating procedures and both visible and/or audible warnings shall be utilized to ensure that unprotected personnel are clear of the Nominal Hazard Zone (NHZ) prior to and during laser operation.

h. Operational Procedures

(1) A specific knowledgeable individual shall be designated as the area laser safety supervisor. No laser shall be operated without this person's approval. He or she may stop a laser operation at any time.

(2) Hazard areas shall be cleared of non operating personnel.

(3) Hazard areas shall be marked with warning signs and lights.

(4) When practical, interlocks shall be installed to shut down the laser in the event of unauthorized personnel intrusion into the NHZ. In any case, engineering controls approved by the laser system safety officer must be utilized. Temporary administrative controls may only be used when approved by the laser system safety officer.

(5) All laser demonstrations shall be in accordance with ANSI Z136.1. The laser operator and LSSO shall ensure that all applicable federal, state, and local requirements are satisfied.

4. Laser Maintenance

a. In some instances a laser product may have received approval from the Center for Devices and Radiological Health (CDRH) and as a class I, II, or IIIa laser during operation. It could, however, contain an embedded class IIIb or class IV laser which changes the class when attenuators, panels, or protective housings are removed for servicing and maintenance. Under conditions in which removal of panels, attenuators, or protective housings, overriding of protective housing interlocks, or entry into the nominal hazard zone (NHZ) becomes necessary, and the accessible laser radiation exceeds the MPE, a temporary laser controlled area shall be devised with the signs and precautions appropriate to the class 3b or 4 laser. Such an area, which by its nature will not have the built in safety features as does a permanent area, shall nevertheless have equivalent safety requirements for personnel within and without. A notice sign shall be posted outside the temporary laser controlled area to warn of the potential hazard. A cap shall be provided to cover the laser radiation exit port to prevent undesired or unauthorized external radiation.

b. Optical fiber systems which contain lasers shall be considered enclosed systems as long as the laser remains fully attached to the cable and the radiation output is confined within a cable system. If disconnection of the laser results in accessible radiation being reduced below the MPE by engineering controls, connections or disconnection may take place in an uncontrolled area and no other control measures are necessary. But if radiation is above the MPE, connection or disconnection during operation and continued operation after disconnect must take place in a laser controlled area as described in paragraph 4a. Any laser fiber optic connector which is not inside a secured equipment enclosure shall be labeled with caution or danger appropriate to the laser and only be disconnectable by the use of a tool. While no tool for connector disconnection is required when the connector is located inside a secured equipment enclosure, caution or danger signs appropriate to the class of the laser shall be located near the connectors and shall be visible when the enclosure is open.

Apply the following general rules when servicing optical fiber systems:

(1) The presence of an LSSO is not required.

(2) The power of optical fiber systems is currently less than 0.5 watts and worst case procedures would be for Service Group 3b.

(3) While there is usually no hazard to the unaided eye beyond one meter, a lens or eye loupe can increase the hazard beyond that distance.

(4) Label disconnectable components and connectors.

(5) Verify continuity with an optical test set.

(6) Train employees not to look into broken or disconnected cable.

(7) Establish a controlled area for servicing.

c. All safety devices including cutouts and eyewear shall be checked and maintained on a regular basis. Eyewear shall be checked to ensure also that the markings for wavelength and optical density are still legible.

d. For all class 3b and class 4 lasers, maintenance personnel potentially exposed to hazardous levels of radiation shall wear protective eyewear marked for the appropriate wavelength and optical density whenever a possibility of firing the laser exists or where personnel may be exposed to collateral radiation.

e. During maintenance, hazardous levels of laser radiation shall be confined to prevent exposure of unprotected personnel.

Such confinement may consist of:

(1) An enclosure which safely confines the radiation with no specular (mirror-like) reflections, and is adequately interlocked or guarded and provided with exterior warning lights (if practical) and warning signs similar to Figure 9-1.

(2) An output lens cap which safely confines the radiation whenever practical.

f. Since the greatest danger from lasers is due to large capacitance at high voltage, all electrical safety precautions of OPNAVINST 5100.19B, the Electronics Installation and Maintenance Book(EIMB), NAVSEA 0967-LP-000-0100, OSHA standards 29 CFR Parts 1910 and 1926, and SPAWARINST 5100.9D shall be strictly enforced, especially in the use of grounding rods to discharge capacitors and the two man rule. All external cabling shall be interlocked within the enclosure and of the female type (hot side) for voltage sources over 30 volts.

g. Precautions and protection shall be provided against noise in excess of 84 dB(A), radiation, hazardous material such as some lens coatings and connector compounds, toxic or inert gases, cryogenics, mechanical hazards, radiation through viewing ports, and other recognized hazards.

5. Procedures and Precautions for the Safe Use of Airborne Lasers on Approved Ranges.

Recommendations for airborne lasers that need to be instituted to safely conduct laser operations are as follows:

a. A log shall be kept by the range, showing the date, time, and number of all laser firings.

b. The target and the target area must be free of any specular reflectors (mirrors, glass, still water, etc.).

c. Range boundaries must be posted to advise the public of the presence of laser operations.

d. Unprotected personnel shall not be allowed to view the laser beam or its specular reflection from within the beam path and its associated buffer, with or without optics. Such eye protection shall have curved lenses and an optical density as specified in reference (h).

e. All future targets must be free of mirror-like (specular) reflective objects).

f. Only the authorized target may be designated or ranged.

g. Do not designate or range on still water, flat glass, mirrors, glazed ice, plexiglass, or any other specular reflector.

h. Do not designate or range on other aircraft.

i. Prior to lasing, the target must be positively identified under the cross hairs of the scope or on the operator's monitor.

j. Lasing shall cease if the operator or range control is dissatisfied with target tracking.

k. Lasing shall cease if unprotected or unauthorized personnel enter the laser hazard area.

l. A flyover of the range shall be made to ensure that no unprotected or unauthorized personnel are in the laser hazard area. This includes fishing boats where island or shoreline ranges are involved.

m. Lasing shall cease if unprotected or unauthorized aircraft, ships or vehicles enter the operations area or the buffer zone between the lasing aircraft and the target. The buffer zones for various systems are defined in reference (h).

n. Two-way communication must be maintained between the laser system operators and all affected range personnel.

o. An operator training program shall be established as required by SPAWARINST 5100.12B and ANSI Z136.1-1993.

p. Laser operations personnel shall periodically read and agree always to follow the SOP.

q. Laser operations shall take place only on laser approved ranges established in accordance with SPAWARINST 5100.12B.

r. No special precautions are necessary for firing during rain, fog, or snowfall. Certain ranges should be closed to laser operations if water begins ponding either on the ground, snow, or ice.

s. A "Pre-mission Brief" shall be conducted prior to laser operations. The brief shall include as a minimum:

(1) Maps depicting the targets and target areas and associated laser hazard areas.

(2) Drawings or photographs of the targets to be utilized.

(3) Discussion of run-in headings and flight profiles for airborne lasers.

t. No class 3 or 4 laser shall be directed above the horizon unless coordinated with the Federal Aviation Administration and all DOD components including HQ US Space CMD/J3SOCO Suite 9-101, 1 NORAD Rd, Cheyenne Mountain AFB, CO 80914-6020, Attn: SPADOC Laser Clearinghouse, DSN 268-3510, (719) 575-3510.

6. Procedures and Precautions for the Safe Use of Ground Based or Ship Based Lasers on Approved Ranges.

Recommendations that need to be instituted to safely conduct laser operations are as follows:

a. A log shall be kept by the range, showing the date, time, and number of all laser firings.

b. The target and the target area must be free of any specular reflectors (mirrors, glass, still water, etc.).

c. Range boundaries must be posted to advise the public of the presence of laser operations.

d. The laser must always be pointed downrange (toward the target).

e. All personnel in the immediate area of the laser firing position must be behind the operator while the laser is in use. Laser eye protection need not be worn by laser operators nor by observation personnel viewing the target area with binoculars as long as they remain in this position. But personnel should never wander into the beam path, its associated buffer, or the laser target area without appropriate laser eye protection. All down-range personnel shall wear laser eye protection. Such eye protection shall have curved lenses and an optical density (OD) at the laser wavelength as specified in MIL-HDBK-828.

f. Only the authorized target may be designated or ranged.

g. Still water, flat glass, mirrors, glazed ice, plexiglass, or any other specular reflector shall not be designated or ranged upon.

h. Aircraft, ships, vehicles, or personnel shall not be designated or ranged upon unless specifically authorized by the LSSO and upon determination that affected personnel have donned laser protective eyewear.

i. Prior to lasing, the target must be positively identified under the cross hairs of the scope or on the operator's monitor.

j. Lasing shall cease if the operator or range control is dissatisfied with target tracking.

k. Lasing shall cease if unprotected or unauthorized personnel enter the laser hazard area.

l. The laser will not be operated or used experimentally outside the range area without such operation being specifically authorized by the local laser system safety officer.

m. The laser exit port of all ground based laser systems will be covered by an opaque dust cover when the laser is located outside the range area or is not in use.

n. No special precautions are necessary for firing during rain, fog, or snowfall. Certain ranges should be closed to laser operations where still water conditions have not already been approved by the LSSO or if water begins ponding either on the ground, snow, or ice.

o. Laser operations personnel shall periodically read the range SOP and agree to follow it at all times.

p. Personnel must report to their supervisor immediately any suspected injury or defective equipment (e.g., misalignment of the laser beam with the pointing optics) so the appropriate action can be taken.

q. An operator training program as required by SPAWARINST 5100.12B and ANSI Z136.1-1993 must be established.

r. A medical surveillance program as required by BUMEDINST 6470.2A and ANSI Z136.1-1993 must be established.

s. Operation shall be permitted only on the laser approved range established in accordance with this instruction.

t. Two-way communication must be maintained between the laser system operators and all affected range personnel.

u. A "Pre-mission Brief" shall be conducted prior to laser operations. The brief shall include as a minimum:

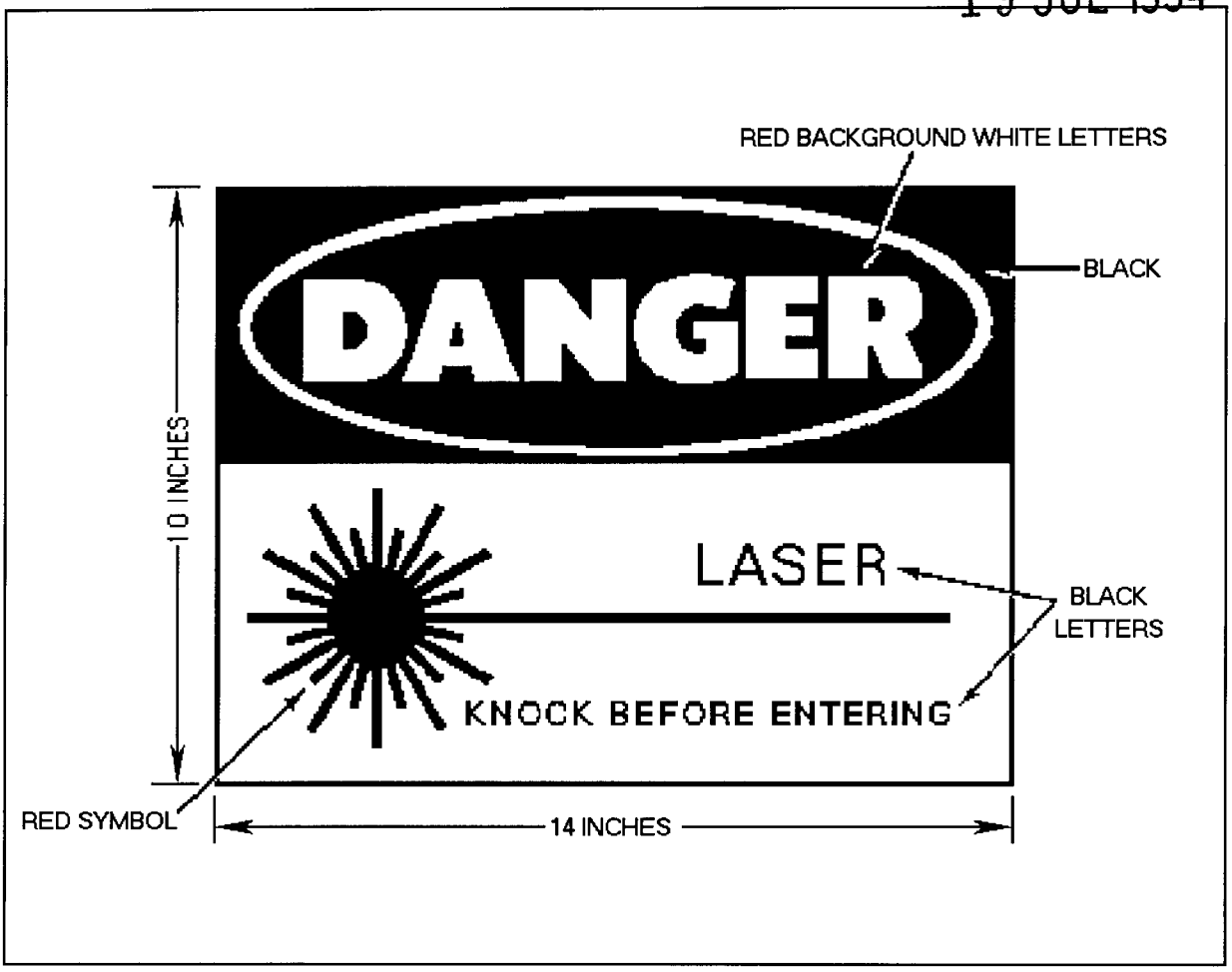
(1) Maps depicting the targets, target areas, and associated laser hazard areas.

(2) Drawings or photographs of the targets to be utilized.

(3) Permissible firing fans.

v. No class 3 or 4 lasers shall be directed above the horizon unless coordinated with the Federal Aviation Administration and affected DOD components, including HQ US Space Command/J3SOCO Suite 9-101, 1 NORAD Rd, Cheyenne Mountain AFB, CO 80914-6020, Attn: SPADOC Laser Clearinghouse, DSN 268-3510, (719) 575-3510.

7. Laser Range Survey Checklist. A Laser Range Survey Checklist shall be used similar to that shown in MIL-HDBK-828.

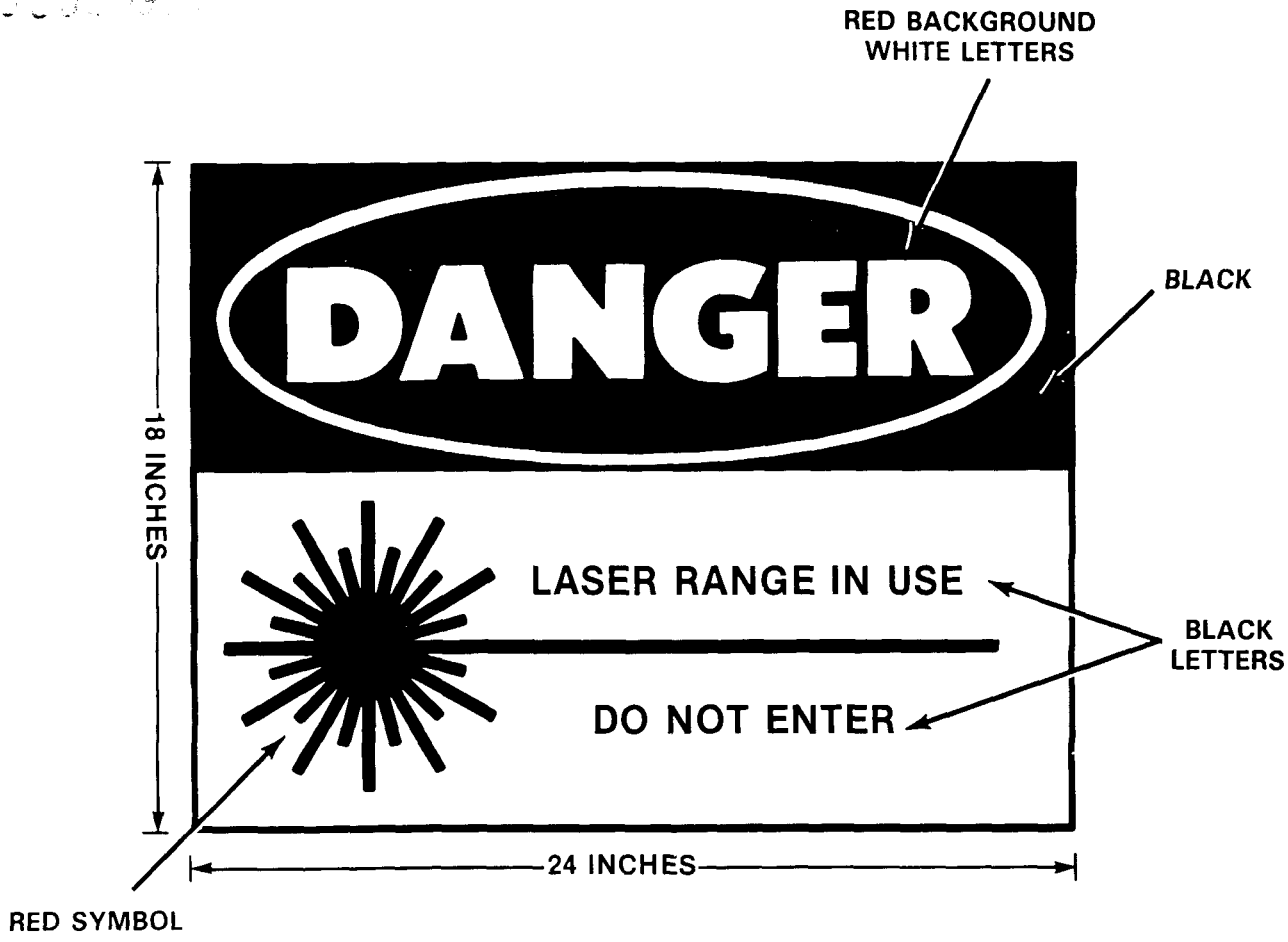


Form No. 0177LF0000700

Available from: Aviation Supply Office
Naval Publications and Forms Division
5801 Tabor Avenue
Philadelphia, PA 19120-5099

Order on DD FORM 1348. Provide cost accounting data. Cost $7.60

Figure 9-1. Laser Maintenance Area Warning Sign



Form No: 0177LF0000500

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Philadelphia, PA 19120-5099

Order on DD FORM 1348. Provide cost accounting data. Cost $23.50

Figure 9-2. Laser Range Warning Sign

LASER FIRING LOG

19 JUL 1994

Command _____

Range _____

Date _____

System _____

User _____

Mission Commander _____

Firing #	Time	Target Location	Firing Position/Heading

Figure 9-3. Sample Laser Firing Log.

LASER CLASSIFICATION AND LABELING

1. Lasers. All lasers must be classified and labeled by the manufacturer according to CFR Title 21, Part 1040.10 or MIL-STD-1425 for military exempt lasers. Figure 10-1, sheets (1) and (2), show typical signs in compliance with 21 CFR. Figure 10-1, sheets (3) and (4), show typical signs for military exempt lasers in compliance with MIL-STD-1425. This classification system is based on laser output parameters. Lasers complying with 21 CFR usually have classification numbers with roman numerals. Military exempt lasers complying with MIL-STD-1425 will have classification numbers with arabic numbers. However, in almost all instances the use of arabic numbers in this instruction will refer to both 21 CFR compliant and military exempt lasers. The laser classes and required signs and labels for posting are:

a. Class 1 Lasers. Lasers which by inherent design cannot emit radiation levels in excess of the maximum permissible exposure (MPE) limits. Safe limits are defined in 21 CFR for each wavelength and emission duration. Only a certification label is required.

b. Class 2 Lasers. Low power lasers and laser systems which emit less than 1 mw visible (from 0.4 to 0.7 micrometers) CW radiation. These lasers are not considered hazardous for momentary (less than 0.25 seconds) unintentional exposure. Repetitively pulsed visible lasers which exceed class 1 accessible emission limits (AEL) for the maximum possible duration inherent in the design or use of the laser, but do not exceed class 1 AELs for 0.25 seconds of exposure are also class 2 lasers. (Refer to figures 10-1a and 10-1e.). Class 2a lasers are class 2 lasers which are not intended to be viewed, such as some supermarket scanners.

c. Class 3 Lasers. Medium power lasers and laser systems. Table 10-1 summarizes power or energy emissions for some class 3 lasers. A detailed explanation should be obtained from ANSI Z-136.1. Visible class 3 lasers with output power between one and five milliwatts are class 3a lasers. Invisible lasers (less than 0.4 micrometers and greater than 0.7 micrometers) and having output power between 1 and 5 times the Class 1 accessible emission limit (AEL) shown in table 1 of ANSI Z136.1-1993 are also class 3a. All other class 3 lasers at all wavelengths which have a power less than 500 milliwatts and energy as shown in table 10-1 are defined as class 3b. As shown in figure 10-1b, the signal phrase "Caution. Do not stare into beam or view with optically aided devices." shall be used with all signs and labels associated with class 3a lasers which have an output irradiance less than 2.5 milliwatts per square centimeter. The signal word "Danger" and a phrase similar to that shown in Figure 10-1c shall be used with all class 3b lasers and class 3a lasers with greater than 2.5 milliwatts per sqare centimeter output irradiance. (See figures 10-1b, 10-1c, 10-1f, 10-1g, 10-1h, and 10-1i.)

d. Class 4 Lasers. High power lasers and laser systems. This includes all lasers in excess of class 3 limitations. The signal word "Danger" shall be used on all signs and labels associated with the class 4 laser. (Refer to figures 10-1d, 10-1h, and 10-1i.)

e. Invisible Radiation. For all invisible radiation (less than 0.400 micrometers or greater than 0.700 micrometers, the word "invisible" shall precede the word "radiation" on all warning signs and labels. (See figures 10-1c, 10-1d, 10-1g, 10-1h, and 10-1i.)

f. Each class 2, 3, and 4 laser product which is not military exempt must also be labeled with the maximum power output of the laser radiation, the

pulse duration when appropriate, and the laser medium or emitted wavelength. Military exempt lasers must be labelled with the class and all precautionary actions to be taken per MIL-STD-1425A (See figures 10-1e through 10-1i.

2. Military Exempt Label. As specified in figure 10-2, each military exempt laser shall be marked with a label indicating its exemption from the requirements of 21 CFR Part 1040. Other labels shall be provided as required by MIL-STD-1425.

2. Optical Fiber Communication System (OFCS) Classes

The classification of a laser is based on the ability of the optical beam to cause damage to the eye. Under normal operating conditions, an OFCS is inherently an eye safe system. But when an optical fiber connection is broken and optical instruments are used, it is possible that hazardous energy can enter the eye. For this reason, four service group (SG) hazard classes have been devised to indicate the degree of hazard and required hazard control measures associated with OFCSs. These definitions are based strictly on the optical radiation hazard and do not take into account other potential hazards. The information which follows is a brief description of each class. Refer to ANSI Z136.2 for a full technical definition.

a. SG1: An OFCS is classified Service Group 1 if the laser or LED cannot emit accessible levels of optical radiation in excess of the maximum permissible irradiance (MPI) levels. A SGI OFCS is exempt from all control measures and from any form of surveillance.

b. SG2. An OFCS is classified Service Group 2 if the laser or LED emits in the visible (0.4 - 0.7 micrometers) spectrum a total accessible radiant power exceeding the MPE but not in excess of one milliwatt. These low power visible OFCSs stimulate eye reflexes which generally cause a person to look away from the beam before eye damage occurs even when optical aids are being used. The word "CAUTION" should appear on all SG2 labels and signs.

c. SG3a: An OFCS is classified Service Group 3a if the laser or LED beam stimulates the eye reflexes to turn the eye away before injury occurs. If optical aids are in use, however, this reflex will not provide adequate protection. The word "CAUTION" should also appear on all SG3a labels and signs.

d. SG3b: An OFCS is classified Service Group 3b if the laser or LED poses a hazard to the eye when the direct or specularly reflected beam is viewed with or without optical aids. SG3b OFCSs are considered medium power devices. The word "DANGER" should appear on all SG3b labels and signs.

e. A label shall be posted on each Service Class (SC)2, 3a, and 3b OFCS which indicates the maximum output of laser radiation, the pulse duration when appropriate, and the active medium or emitted wavelength.

f. For all invisible radiation (less than 400 nanometers or greater than 400 nanometers) the word "INVISIBLE" shall precede the word "RADIATION" on all warning signs and labels.

Table 10-1 Class 3B Single Pulse Energy

Wavelength in micrometers	Emission Duration	Energy greater than Class 1 but less than or equal to the following
0.18 - 0.4 1.4 - 10^3	10^{-9} to 0.25 sec.	0.125 Joules
0.4 - 0.7	10^{-9} to 0.25 sec.	0.03 Joules
0.7 - 1.05	10^{-9} to 0.25 sec.	$0.03C_A$ Joules (See Table 6 ANSI Z136.1)
1.05 - 1.4	10^{-9} to 0.25 sec.	0.15 Joules

3. For classification and hazard calculations, the limiting aperture and measurement apertures, the maximum circular area over which exposure is averaged, are based on Table 8 and Table 9 of ANSI Z136.1-1993

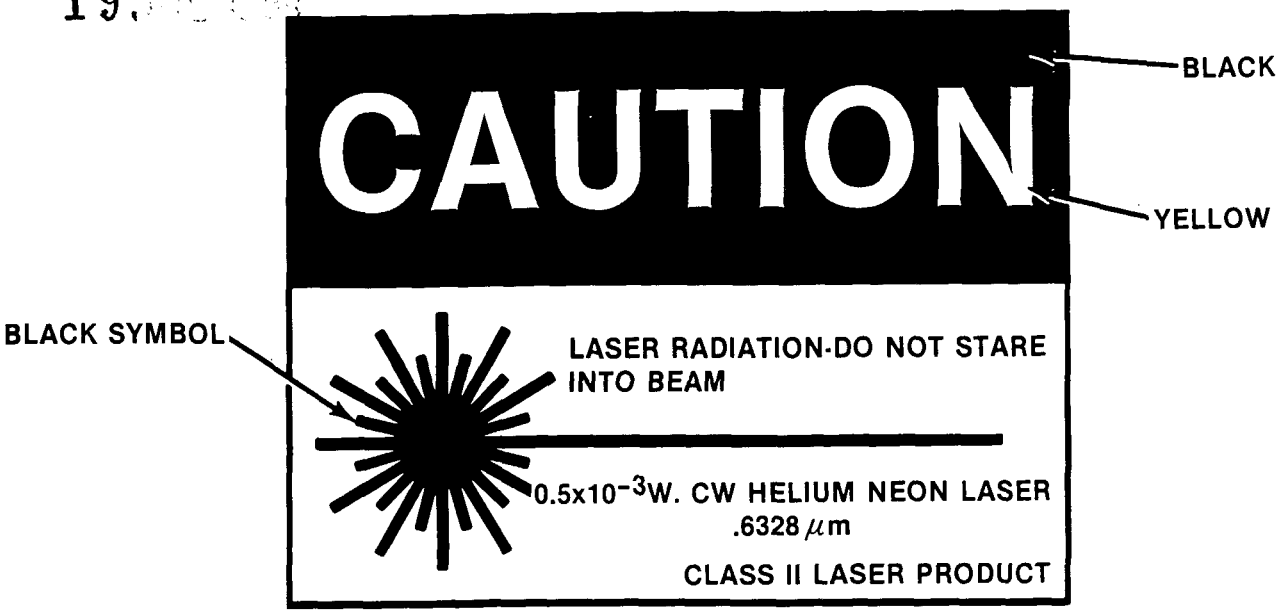


Figure 10-1a. Example of a Laser Class 2 Warning Label According to 21 CFR 1040.10.

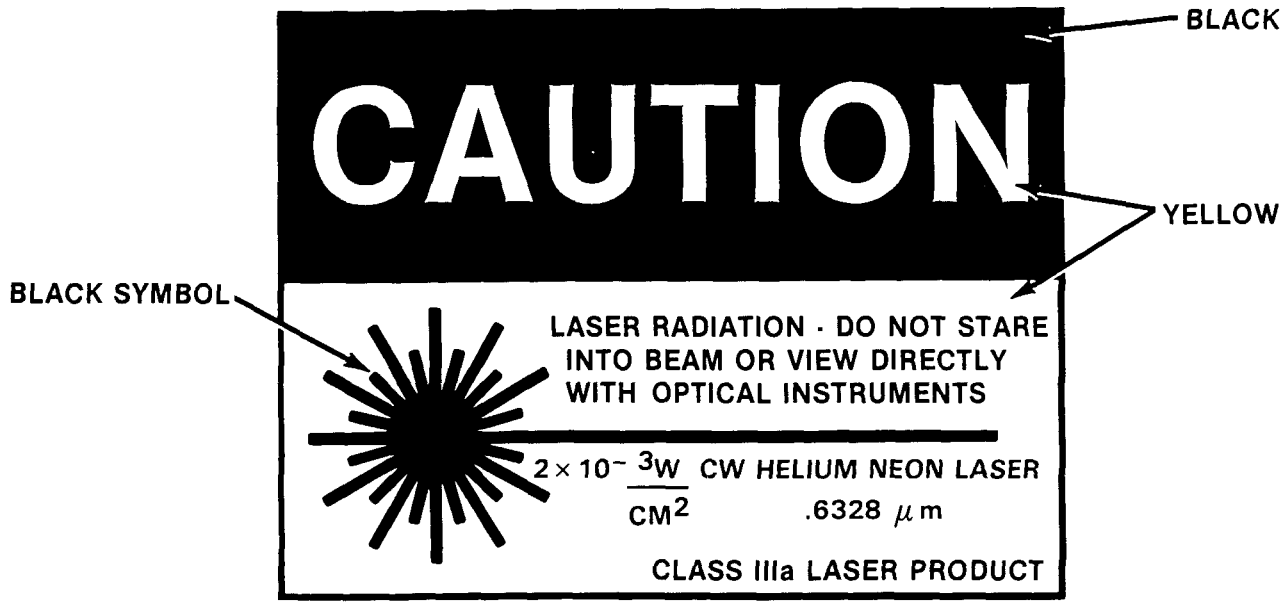


Figure 10-1b. Example of a Laser Class 3a Warning Label According to 21 CFR 1040.10.

Figure 10-1. Examples of Laser Classes 2 through 4 Warning Labels (Sheet 1)

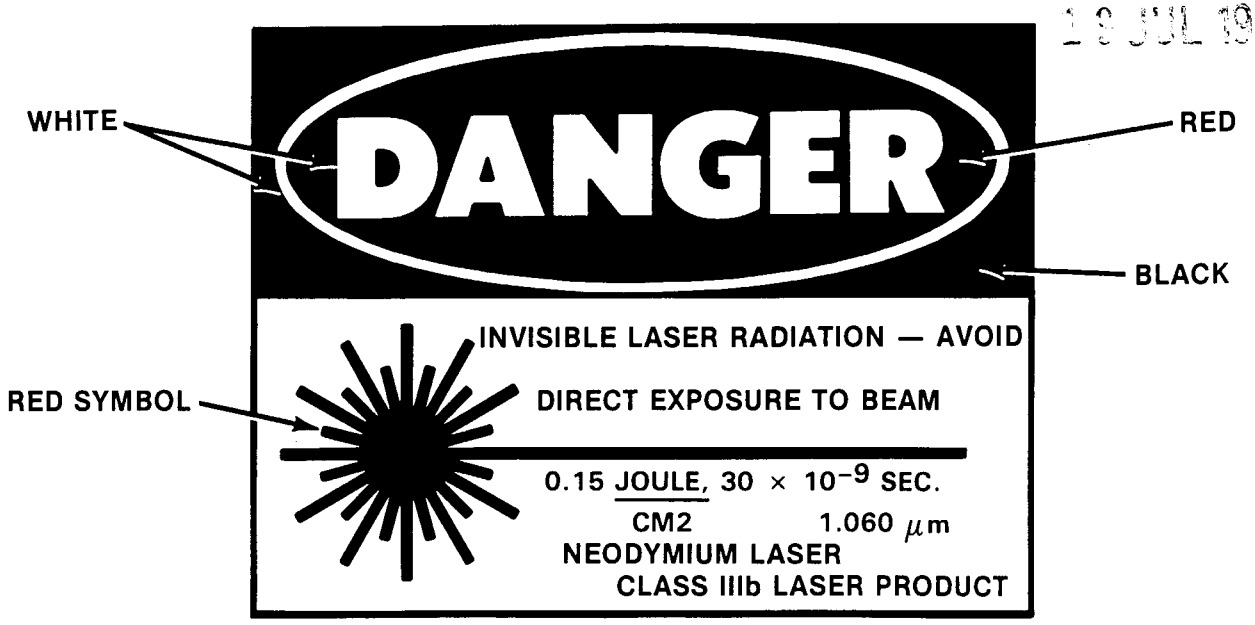


Figure 10-1c. Example of a Laser Class 3b Warning Label According to 21 CFR 1040.10

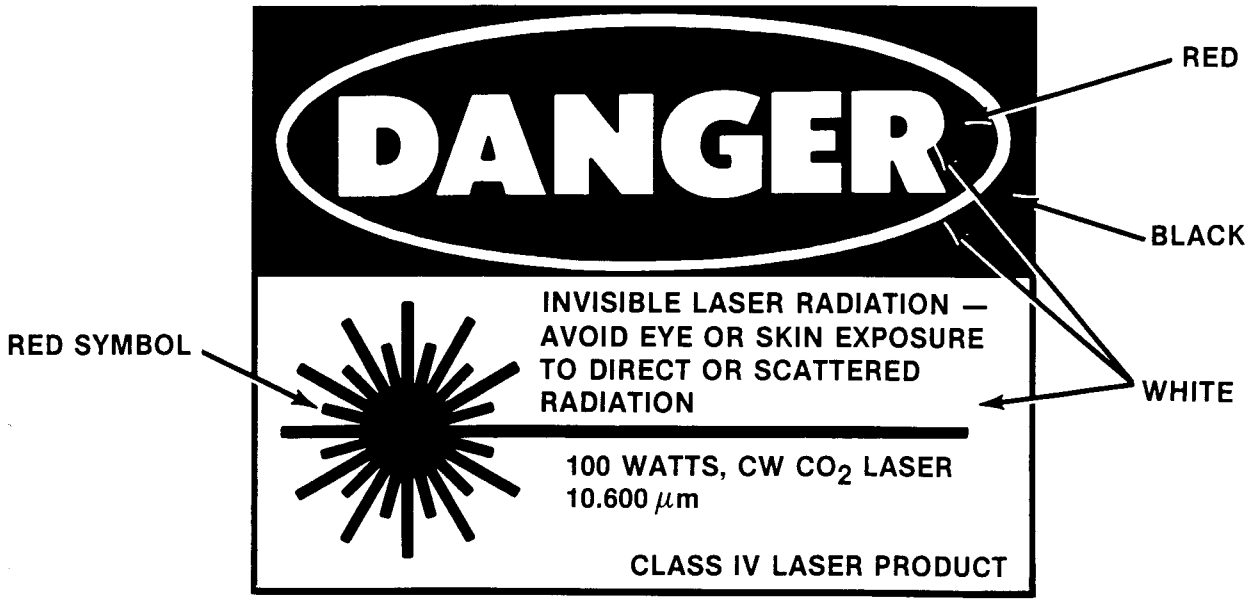


Figure 10-1d. Example of a Laser Class 4 Warning Label According to 21 CFR 1040.10.

Figure 10-1. Examples of Laser Classes 2 Through 4 Warning Labels (Sheet 2)

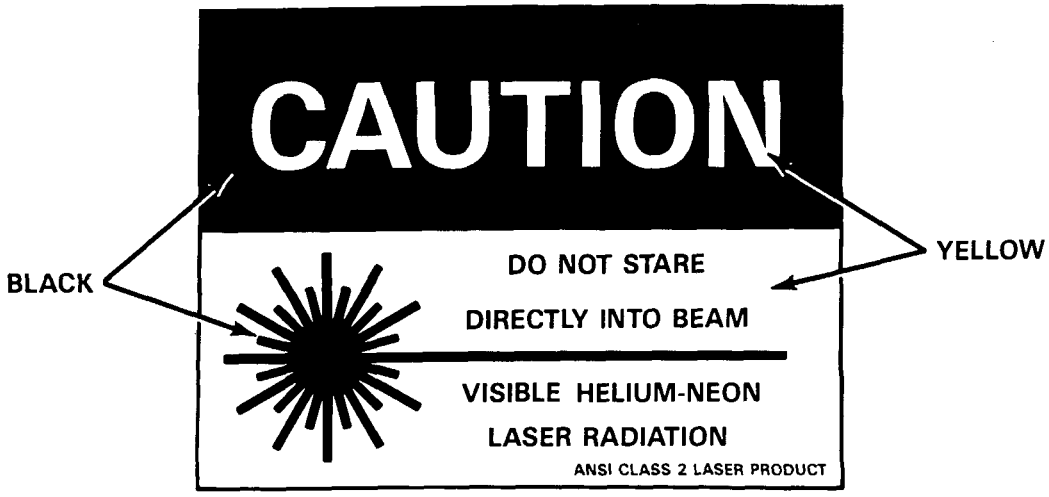


Figure 10-1e. Example of a Class 2 Laser Warning Label According to MIL-STD-1425.

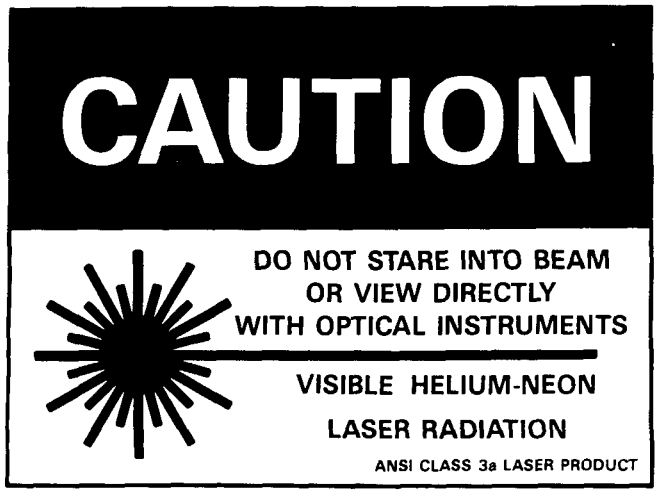


Figure 10-1f. Example of a Class 3a Visible or Near-Infrared Laser Warning Label According to MIL-STD-1425.

Figure 10-1g. Example of a Class 3a Infrared or Ultraviolet Laser Warning Label According to MIL-STD-1425.

Figure 10-1. Examples of Laser Classes 2 through 4 Warning Labels (Sheet 3)

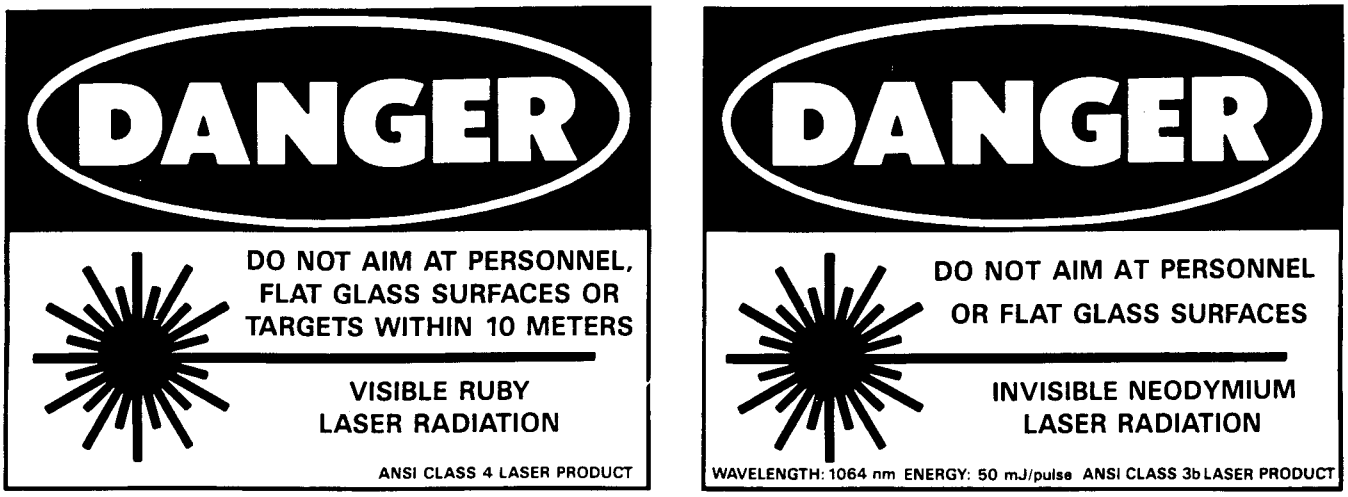


Figure 10-1h. Examples of Class 3b and Class 4 Visible and Near-Infrared Laser Warning Labels According to MIL-STD-1425.

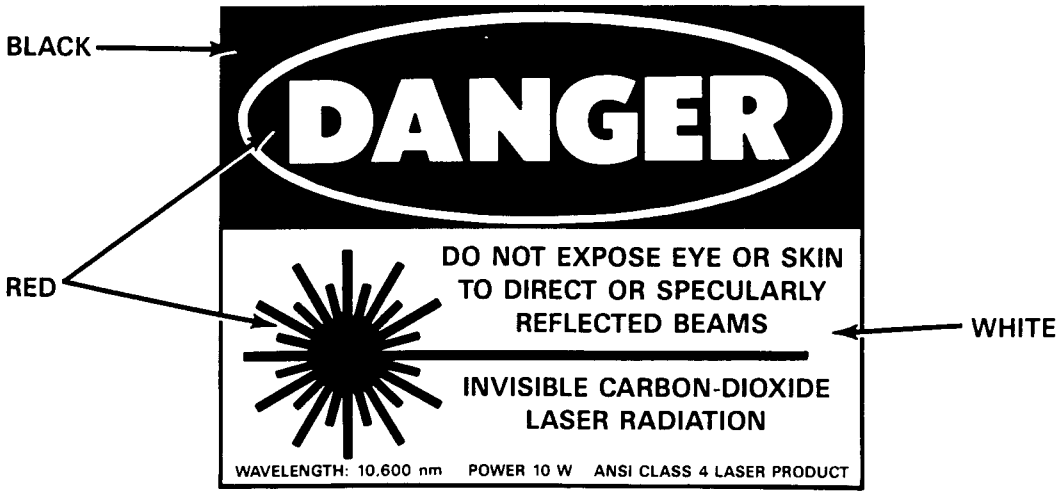


Figure 10-1i. Example of a Class 3b and Class 4 Infrared or Ultraviolet Laser Warning Label According to MIL-STD-1425.

Figure 10-1. Examples of Laser Classes 2 through 4 Warning Labels (Sheet 4)

CAUTION

This electronic product has been exempted from FDA radiation safety performance standards prescribed in the Code of Federal Regulations, Title 21, Subchapter J, pursuant to Exemption No. 76EL-01DOD issued on July 26, 1976. This product should not be used without adequate protective devices or procedures.

Figure 10-2. Exemption Label for Military Exempt Lasers

MILITARY EXEMPT LASER INVENTORY FORMAT

From:
To: Commander, Space and Naval Warfare Systems Command
(SPAWAR 00F)

Subj: EXEMPT LASER INVENTORY REPORT FOR FY

INSTRUCTIONS: Lasers should be grouped. All lasers included on one entry sheet must have identical characteristics, i.e., same contract number, same NSN, same function, same delivery date, same disposal date, etc. Only their serial numbers and plant account numbers can be different. List beginning and ending serial/plat account numbers for continuous sequences. If classified, any field except contract number may be left blank for reasons of national security.

System Name_____ AN/_____ Type_____ Class__

Manufacturer_____

Contract Number_____ Total to date in this contract _____

NSN_____ Serial Numbers_____

Approved by LSRB ? (Y)_ (N)_ If no, explain _____

Exemption Qualification (Check applicable boxes)

Combat _____ Training _____ Classified _____

STATUS

Deliveries this FY _____ Total Disposals to date _____

Subtotals: In use ____ Repair_____Storage_____ Await Disposal____

Transferred to:_____

Serial Numbers: _____

ASD Approval Date __/__/__ (mm/dd/yy) Transfer date __/__/__ (mm/dd/yy)

Diposed to:_____

Serial Numbers: _____

ASD Approval Date __/__/__ (mm/dd/yy) Disposal date __/__/__ (mm/dd/yy)

Demilitarized by: Submission to FDA for approval_____ Removal of laser parts____

(For transfers within DOD) Received from:_____

Laser Location _____

Custodian Name_____Phone_____

Signature_____

Enclosure (11)

CLASS 3b AND CLASS 4 LASER INVENTORY FORMAT

From:
To: Commander, Space and Naval Warfare Systems Command
(SPAWAR 00F)

Subj: CLASS 3B AND CLASS 4 LASER INVENTORY FOR FY

Laser Name/Type/Wavelength/Max. Output/Pulse or CW/Class

Manufacturer _____

Serial Numbers _____

Contract Number _____

National Stock Number
(if available) _____

Plant Account Numbers _____

Program/User/Custodian _____

Location(s) _____

Use(s) _____

Custodian's Telephone Number _____

Signature _____

LASER SAFETY REQUIREMENTS SUMMARY	Military Exempt Class					Non-Military Exempt Class										
(X - mandatory (O - optional)						All Locations			Lab/ Test		Indust.		Range		Medical	
	1	2	3a[2]	3b	4	1	2	3a[2]	3b	4	3b	4	3b	4	3b	4
OPNAVINST 5100.23C/ SPAWARINST 5100.12	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SECNAVINST 5100.14B	X	X	X	X	X											
MIL-STD-1425A	X	X	X	X	X	O	O	O	O	O	O	O	O	O	O	O
LSRB APPROVAL	X	X	X	X	X			O	O	O	X	X	X	X	O	O
21 CFR (FDA APPROVAL)						X	X	X	X	X	X	X	X	X	X	X
ANNUAL INVENTORY TO SPAWAR (00F) BY 8/31	X	X	X	X	X				X	X	X	X	X	X	[3]	[3]
APPROVAL FOR DISPOSAL FROM SPAWAR 00F	X	X	X	X	X											
MEDICAL SURVEILLANCE A. INCIDENTAL WORKER (Visual Acuity Test)	O	O	X	X	X	O	O	X	X	X	X	X	X	X	X	X
B. LASER WORKER (Complete Medical Surveillance)	O	O	X	X	X	O	O	X	X	X	X	X	X	X	X	X
T&E BY NSWCDD/NAWC	X	X	X	X	X											
T&E BY NEHC									O	O	X	X	X	X	X	X
CONTRACTING OFFICER NOTIFY CONTRACTOR CONCERNING EXEMPTION AND LABELING PER ENCLOSURE (4).	X	X	X	X	X											
CAUTION LABEL PER MIL-STD-1425		X	X													
DANGER LABEL PER MIL-STD-1425				X	X											
CAUTION LABEL 21 CFR							X	X								
DANGER LABEL 21 CFR									X	X	X	X	X	X	X	X
TRAINING A. LASER WORKERS READ MANUF. LITERAT.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
INFORMAL SAFETY BRIEF			X					X								
FORMAL SAFETY SPECIFIC TRAINING WITH DEMO./NAVY VIDEO				X	X				X	X	X	X	X	X	X	X
B. INCIDENTAL WORKER INFORM BY: POST WARNINGS		X	X	X	X		X	X	X	X	X	X	X	X	X	X
PROVIDE BRIEFING				X	X				X	X	X	X	X	X	X	X
SAFETY OFFICE ANSWERS INQUIRIES	X	X	X			X	X	X								
LSSO ASSIGNED & TRAINED /LASER INST PROMULGATED				X	X				X	X	X	X	X	X	X	X
BUMEDINST 6470.19															X	X
MIL-HDBK-828	X	X	X	X									X	X		

1. For eye protection see following pages. 2. For class 3a with "Danger Logo" (> 2.5 mw/cm^2), advise personnel to handle as if they were class 3b. 3. Send Medical Laser Inventory to NEHC

RESTRICTIONS

Class 1 Lasers	Class 2 Lasers	Class 3a Lasers with CAUTION LABEL
None during operation.	Caution label and prohibition against staring into beam.	Caution label on laser and prohibition against staring into beam or viewing with optical aids.

RESTRICTIONS AT LABORATORIES AND TEST FACILITIES

Class 3b[4] Lasers

*Danger sign and warning light or other indicator on laser and lab entrance.
*Elimination of all unnecessary specular reflectors from beam path and insertion of beam stops around all remaining specular reflectors.
*Beam stops or enclosed beam path.
*Safety procedures for operations and maintenance posted or on hand.
*Flat paint on surfaces (walls, etc.).
*Adequate illumination appropriate to the task.
*Protective eyewear at the specific wavelength and proper OD. (Unnecessary and unsafe use of protective eyewear shall be avoided.)
*Protective eyewear training, inspection, and replacement program in place.
*Entrance interlocks if beam is not enclosed (interlocks may insert beam stop over exit port of laser or disconnect power to laser.), or if other electrical/chemical/physical hazards exist to entrants. Other techniques such as door locks (doors should open for emergency egress and during power loss.), entry alarms, entrance sentries, beam controls, etc., when approved by the LSSO.
*Emergency shutdown switch per MIL-STD-1425.
*Keylock master switch.
*See paragraph 7 of ANSI Z136.1, paragraph 5 and Appendix A of MIL-STD-1425A for more details.

Class 4 Lasers

*Same as Class 3b and also:
*Removal of hazardous diffuse reflectors.
*Nonflammable stops where necessary.
*Skin protection when necessary.
*Special precautions for high energy.

[4] For class 3a with DANGER logo ($\geq$ 2.5 mw/cm^2), advise personnel to handle these as if they were class 3b.

RESTRICTIONS AT INDUSTRIAL AREAS

Class 3b[5] Lasers	Class 4 Lasers
*Application of OSHA standards 29 CFR 1926.54. *Use of lowest power laser feasible. *Use of class 1 and 2 lasers if possible. *Total enclosure of beam path and target where possible or installation of beam stop and barrier. *Operation isolated in a room or fenced area away from other operations or general public. *Two man rule followed.	*Same as class 3b and: *Elimination of hazardous diffuse reflectors *Nonflammable absorbing beam stops where necessary. *Skin protection where necessary. *Special precautions for high energy sources.

*Danger sign and warning light or other indicator on laser and area entrance.
*Removal of all unnecessary specular reflectors from beam path and insertion of beam stops around all remaining specular reflectors.
*Beam stops or enclosed beam path.
*Safety procedures for operations and maintenance posted or on hand. If feasible, at strategic entrances and laser control panels.
(Medical treatment facilities will follow appropriate BUMED instructions and ANSI Z136.3.
*Flat paint or other diffuse reflecting surfaces (wall, etc.).
*Adequate illumination appropriate to the task.
*Protective eyewear training, inspection and replacement program in place.
*Entrance interlocks if beam is not enclosed (Interlocks may insert beam stop over exit port of laser or disconnect power to laser), or if other electrical/chemical physical hazards exist to entrants. Other techniques such as door locks (doors should open for emergency egress and during power loss), entry alarms, entrance sentries, beam controls, etc., when approved by the LSSO.
*Emergency shutdown switch per MIL-STD-1425.
*Keylock master switch.
*See paragraph 7 of ANSI Z136.1, paragraph 5 and Appendix A of MIL-STD-1425A for more details.

[5] For class 3a with DANGER logo ($\geq$ 2.5 mw/cm^2), advise personnel to handle these as if they were class 3b.

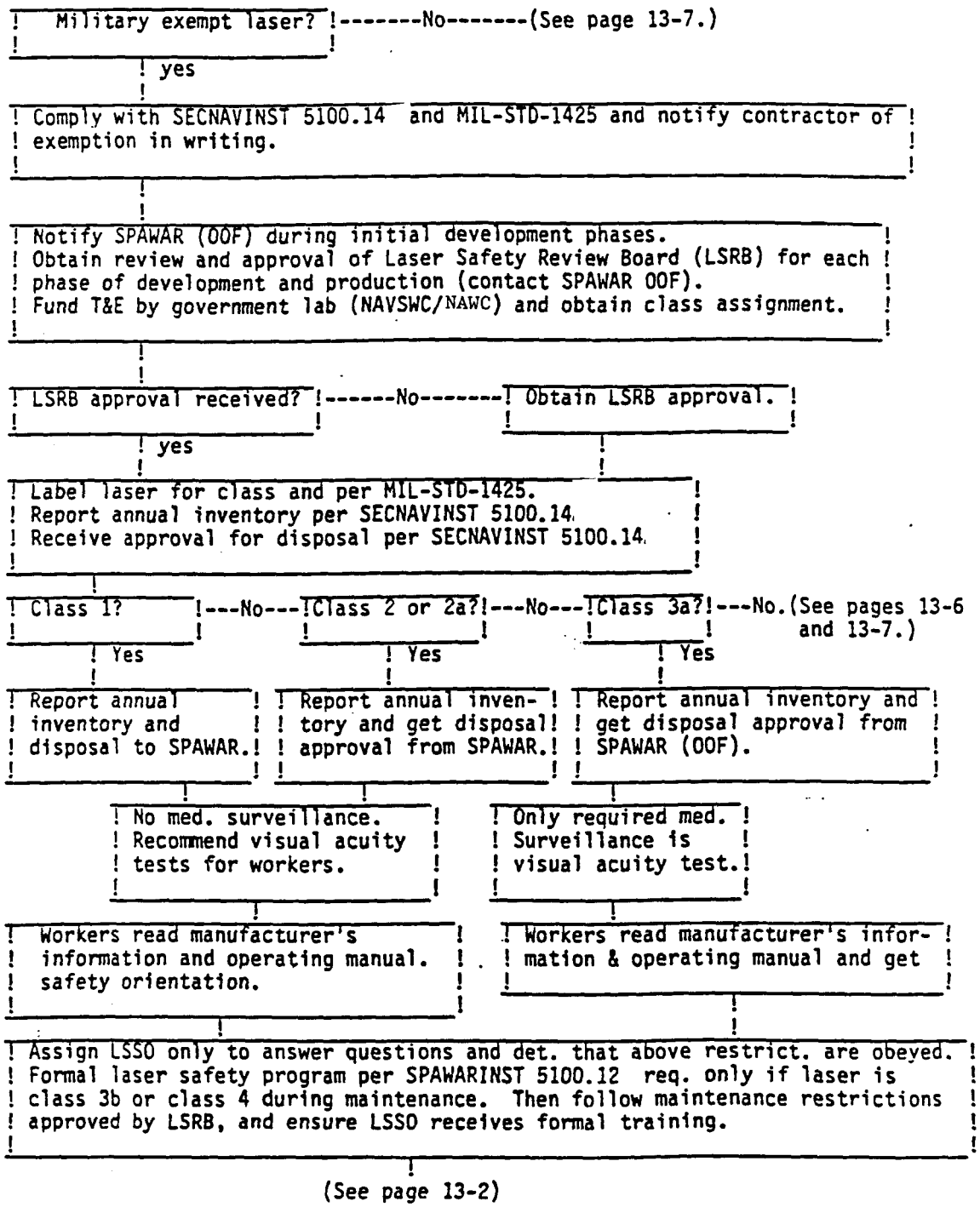
RESTRICTIONS AT RANGES[6]

Class 3b Lasers	Class 4 Lasers
*Laser safety survey and certification by trained and technically qualified LSSO or SPAWAR (00F) designated lab. *Survey and recertification required every three years or after each range modification. *Danger warning signs posted per MIL-STD-1425A and SPAWARINST 5100.12B at *range boundaries and entrances* and at the laser.	*Same as class 3b and: *Elimination of hazardous diffuse reflectors *Nonflammable absorbing beam stops where necessary. *Skin protection where necessary. *Special precautions for high energy sources.

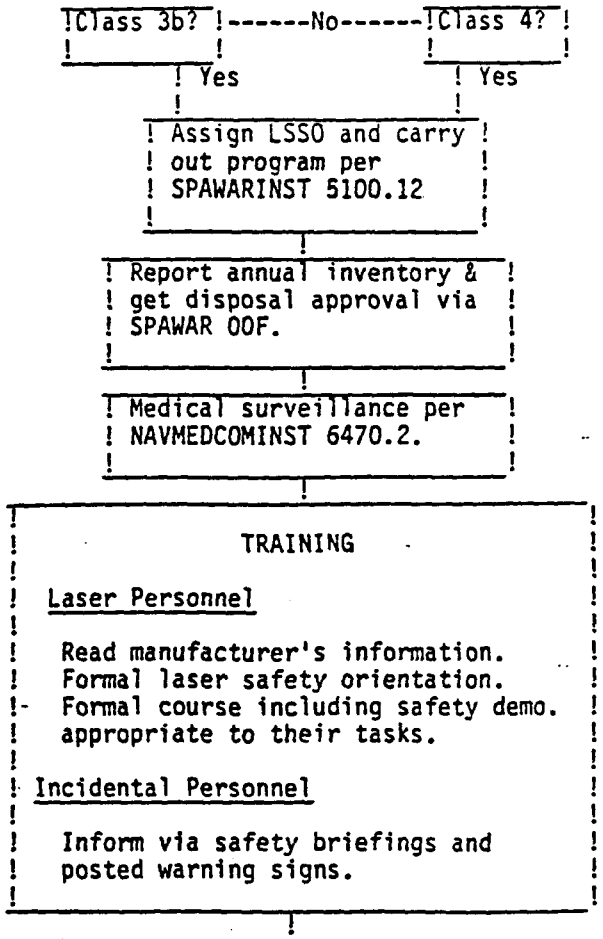
*Barricades with Danger warning signs on access roads to target area.
*Target area, buffer zone, and nonreflecting beam stop assigned for each specific laser.
*Target area and targets free of specular reflectors.
*Protective eyewear at the specific wavelengths and proper OD on personnel in restricted areas (target area and buffer zone).[7]
*Protective eyewear training, inspection, and replacement program in place.
*Range Log of time, date, and heading of laser firing.
*Adequate area surveillance.
*Two-way communications between range safety officer, laser personnel, and restricted area personnel.
*Target in cross hairs on laser sight before lasing.
*Lasing ceased when directed by range control or if unable to keep target in sights.
*A clearing pass by aircraft before lasing.
*Restricted airspace and time established where laser radiation is potentially in flight path of aircraft or satellites.
*Safe flight profile of allowed laser operating altitudes, headings, and distances from target maintained by lasing aircraft.
*Area of restriction established for other aircraft within the nominal hazard distance of the laser.
*Personnel in other aircraft in the restricted cone around the laser line of sight having eye protection of proper OD and wavelength.
*For ground laser operations, assurance that all unprotected personnel are behind the laser and are not within the buffer zone anywhere along the laser line of sight, or between the laser and target or between target and backstop.
*Presence of an LSSO during laser operations.
*All range personnel involved with laser operations trained in laser safety.
*A medical surveillance program in place per BUMEDINST 6470.2A.
*Only lasers approved by the Navy LSRB in use.
*Range adequately fenced to prevent unauthorized entry.

[6]Comply with MIL-HDBK-828.
[7]MIL-STD-1425, Appendix C, provides background on design requirements for laser eye protection.

LASER SAFETY PROGRAM ACTIONS FLOW CHART

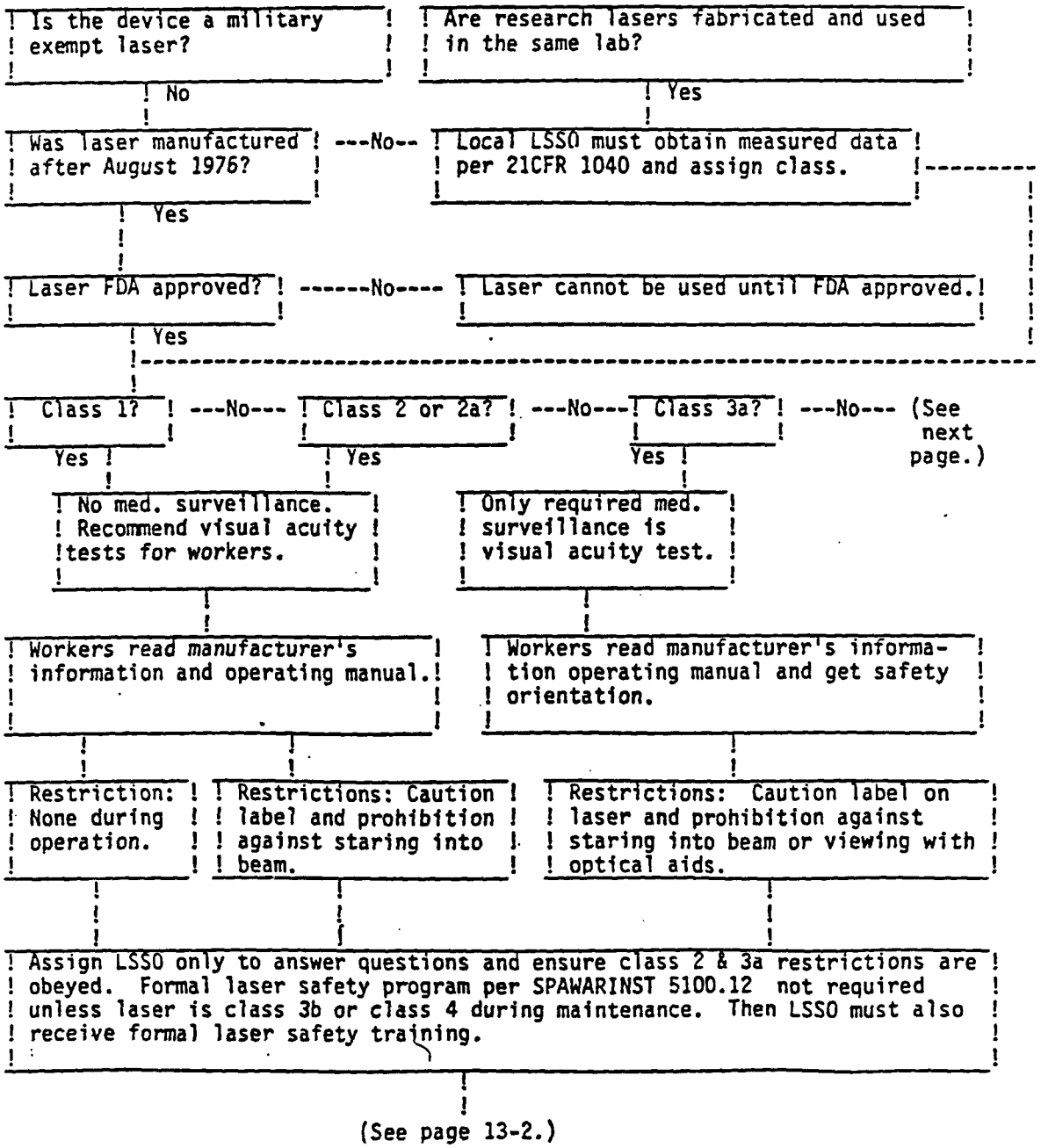


(See page 13-2)

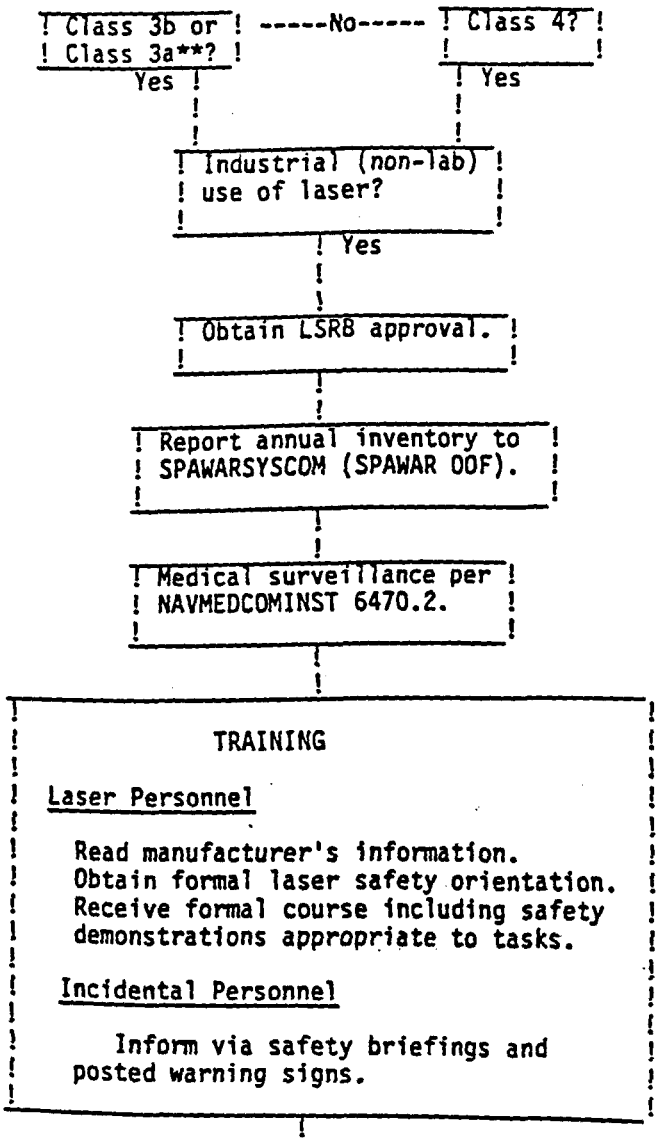


(See pages 13-2 to 13-4.)

Non-military Exempt Lasers



(See page 13-2.)



(See pages 13-2 to 13-4.)

Note

** Class 3a with a DANGER logo (greater than 2.5 mw/cm^2).